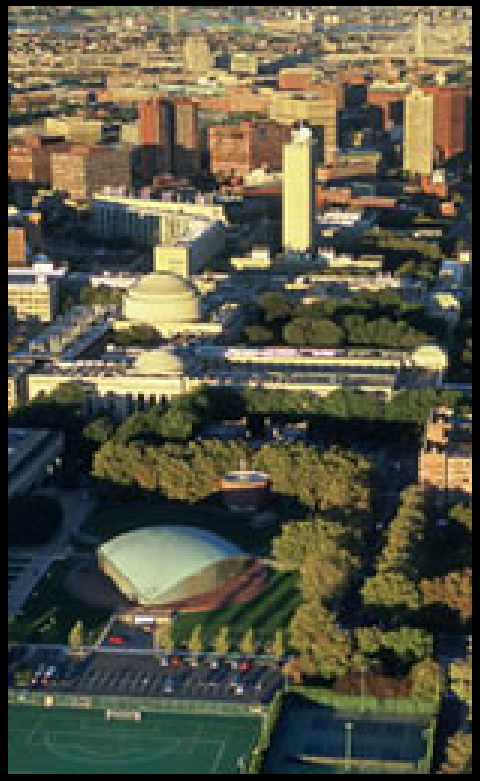
27 February 2008 DRIVE FOR GROWTH Ireland

Can Convergence of Innovation Catalyse Economic Growth ?



Dr Shoumen Palit Austin Datta

Engineering Systems Division
School of Engineering
Massachusetts Institute of Technology

DRIVERS: Sustainable Economic Growth

- Innovation

DRIVERS: Sustainable Economic Growth

- Innovation

Before polishing the chrome, tune the engine!

DRIVERS: Sustainable Economic Growth

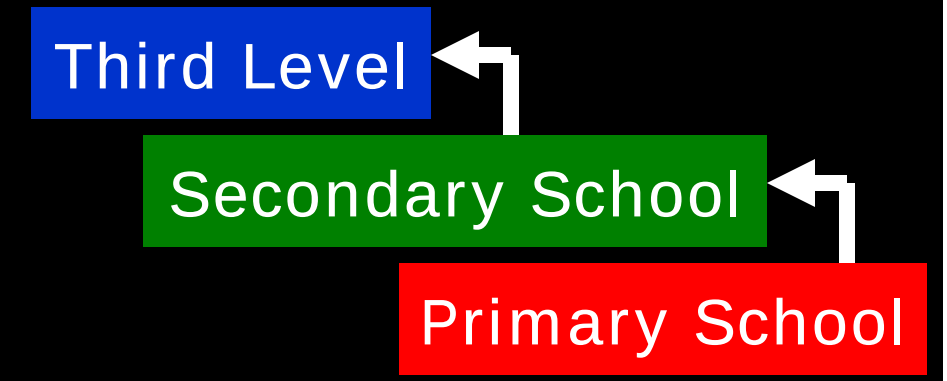
- Innovation >> Invention

Primary School

DRIVERS: Sustainable Economic Growth

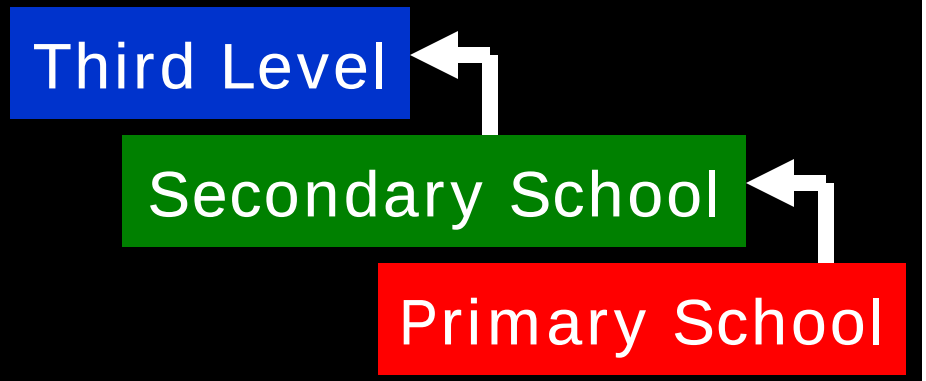
- Innovation >> Invention

  - Students



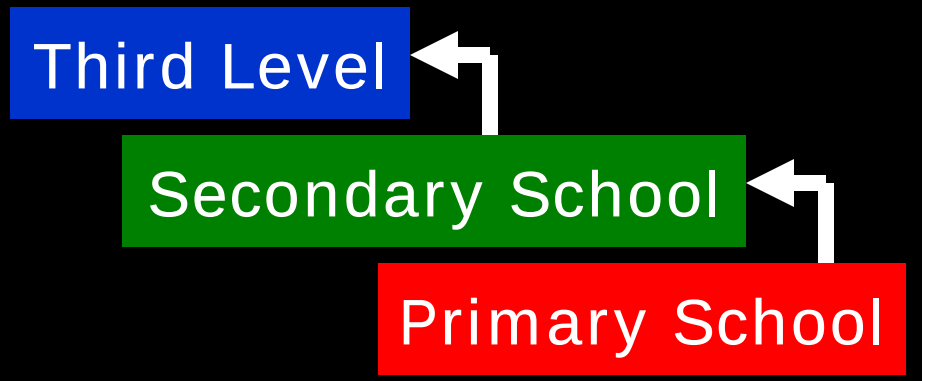
DRIVERS: Sustainable Economic Growth

- Innovation >> Invention
  - Supply Chain of Talent
    - Faculty
    - Students



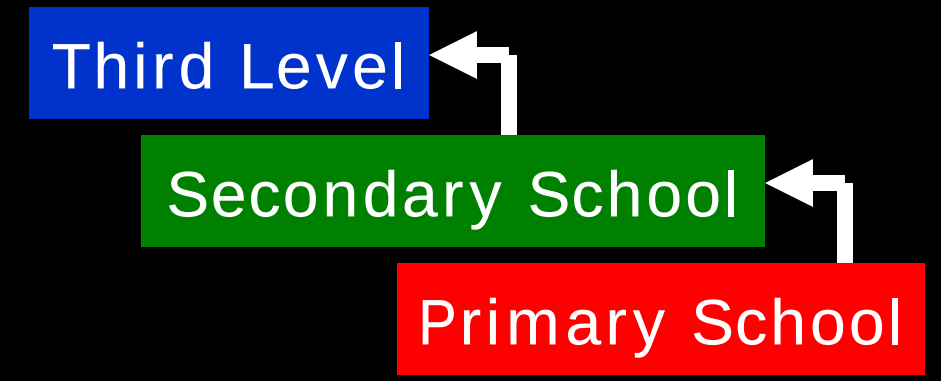
DRIVERS: Sustainable Economic Growth

- Innovation >> Invention
  - University
    - Supply Chain of Talent
      - Faculty
      - Students



DRIVERS: Sustainable Economic Growth

- Innovation >> Invention
  - Research
    - University-Industry Partnerships
    - University
      - Supply Chain of Talent
        - Faculty
        - Students



DRIVERS: Sustainable Economic Growth

- Innovation >> Invention

Before polishing the chrome, tune the engine!

- Students
  - Third Level
  - Secondary School
  - Primary School

DRIVERS: Sustainable Economic Growth

51% of math teachers in US public schools never took math as a part of their college.

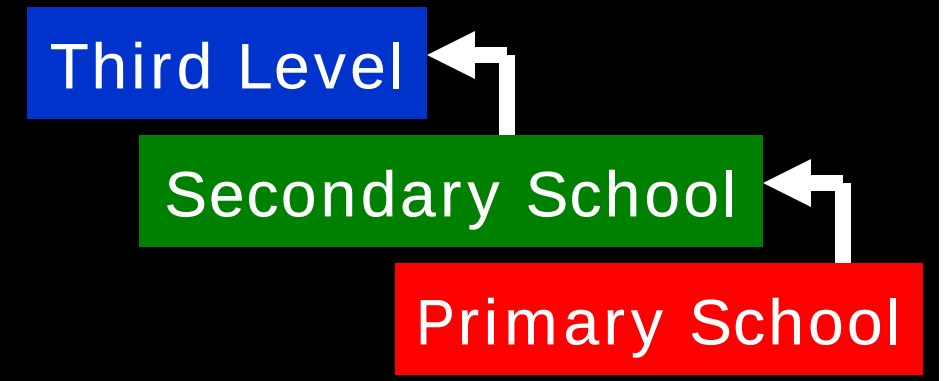
33% of science teachers never took science as a major in college.

1.2% of high school seniors enrolled in advanced physics.

18% of physics teachers had degrees in physics.

Source: Carnegie Foundation, NY

- Students



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Why is "USA still the cradle of innovation" ?

Source of Quote: World Economic Forum, 2008

DRIVERS: Sustainable Economic Growth

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DRIVERS: Sustainable Economic Growth

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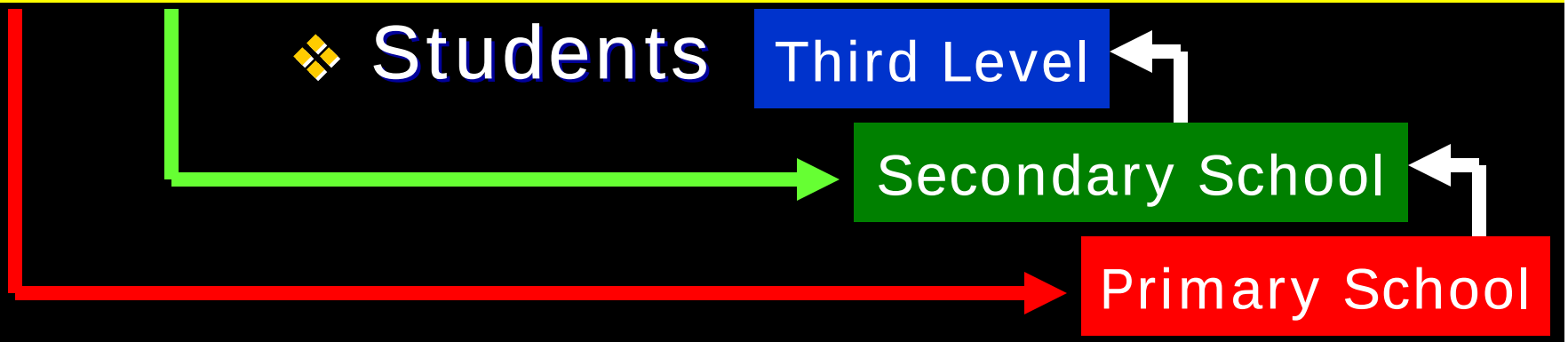
Ireland ?



DRIVERS: Sustainable Economic Growth

- Innovation

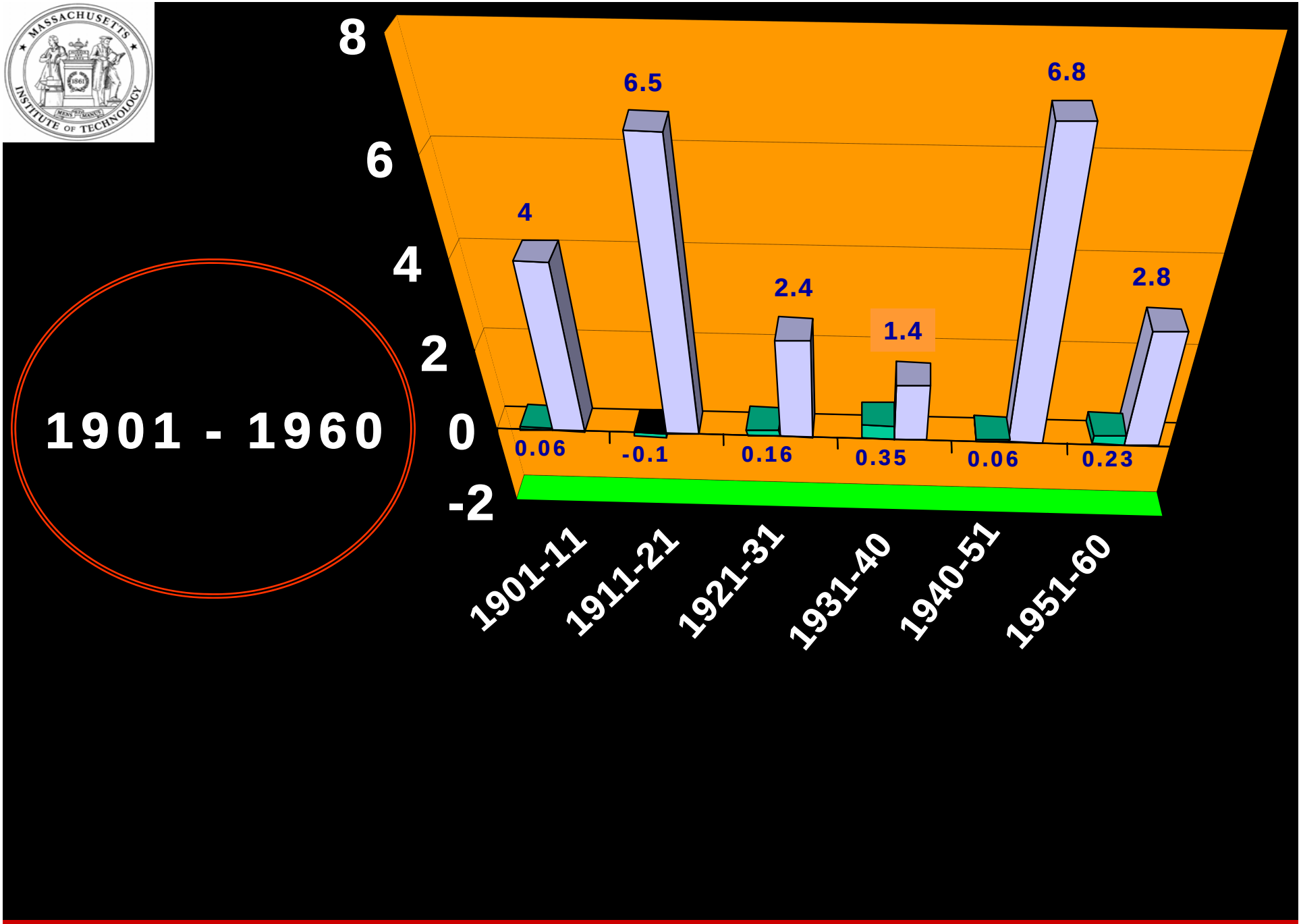
Partnerships

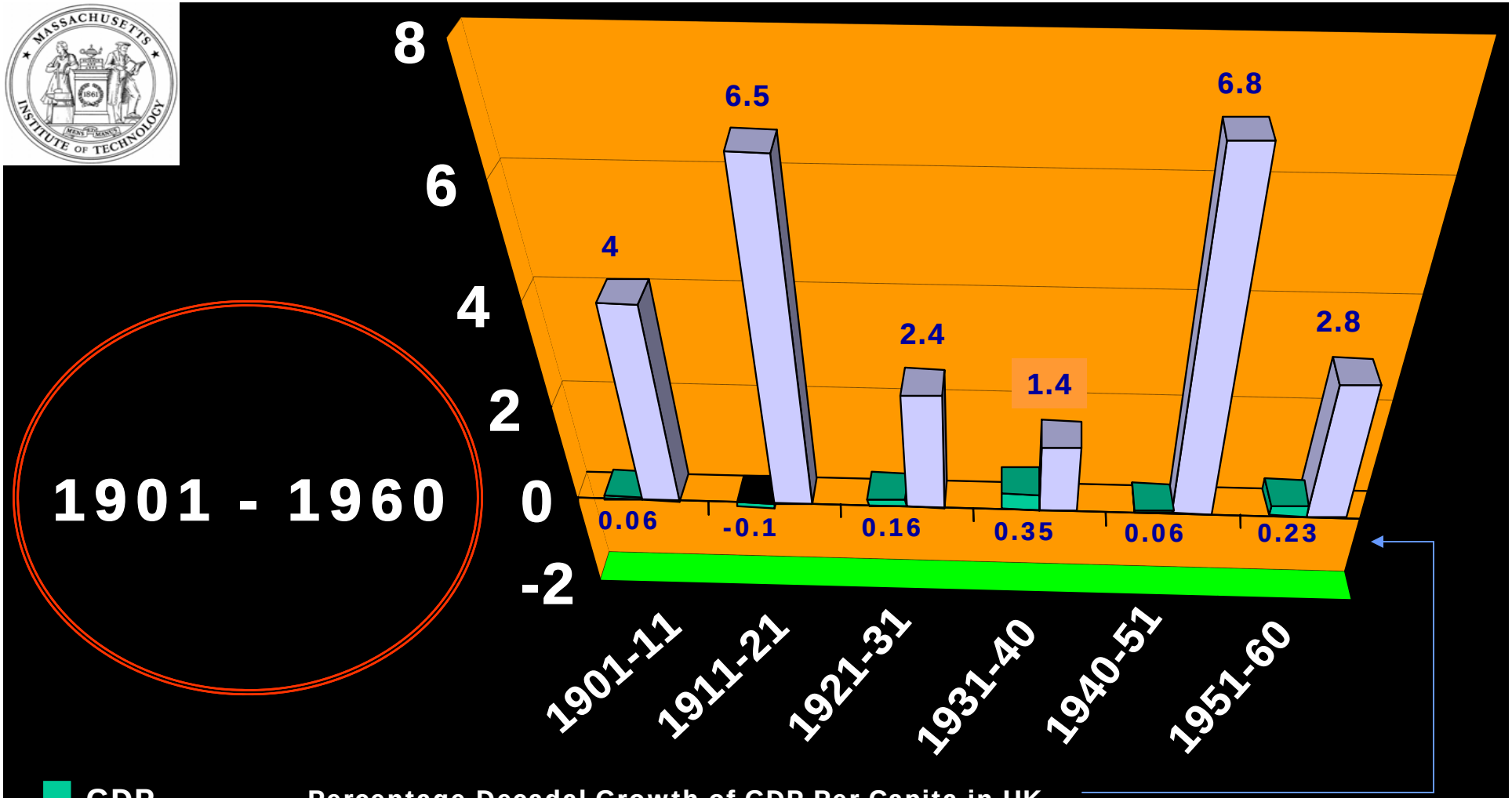
DRIVERS: Sustainable Economic Growth

- Innovation

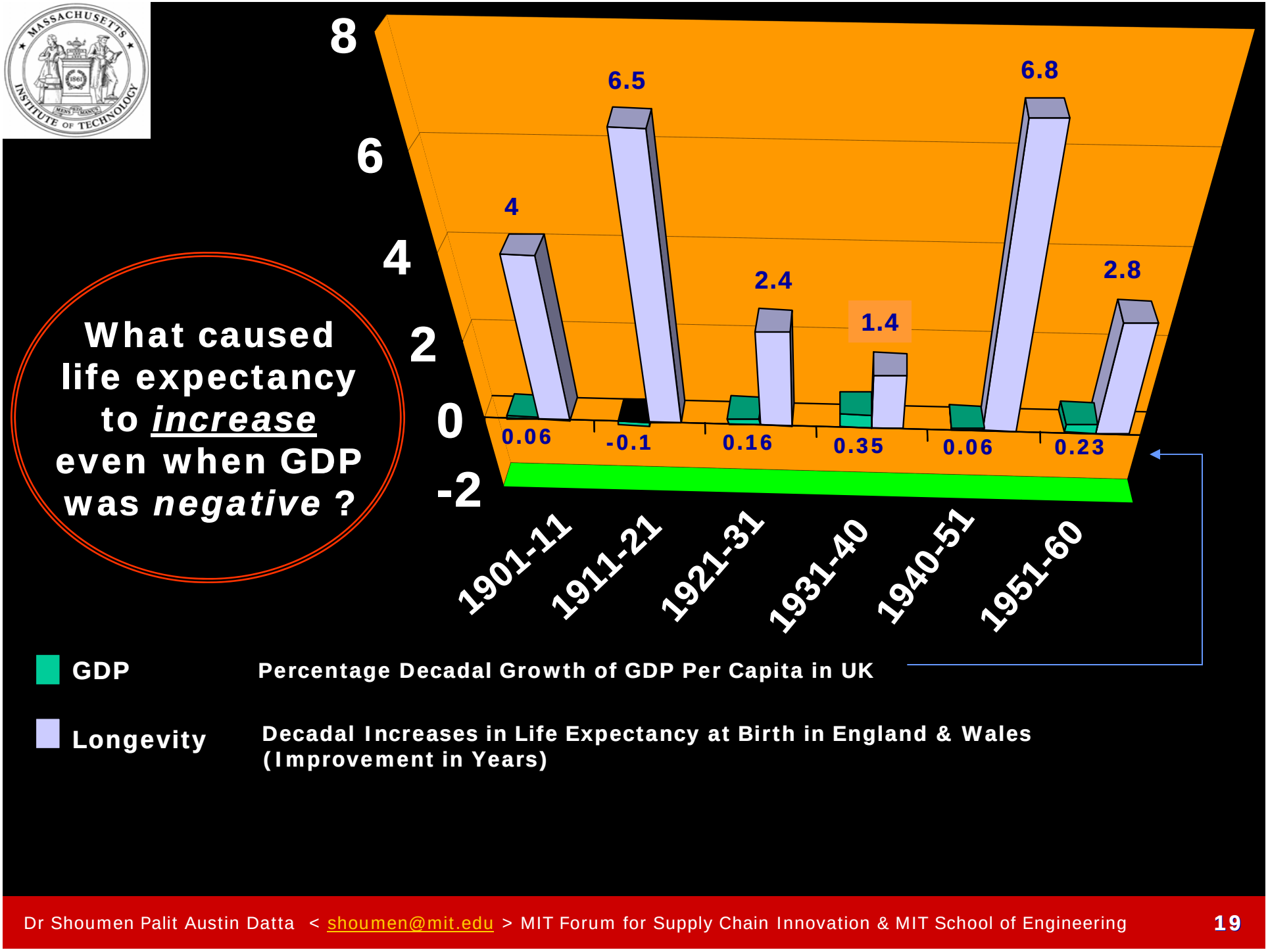
1901 - 1960

Partnerships


1901 - 1960
8
6
4
2
0
-2
4
6.5
2.4
1.4
6.8
2.8
0.06
-0.1
0.16
0.35
0.06
0.23
1901-11
1911-21
1921-31
1931-40
1940-51
1951-60



S. Preston, N. Keyfitz and R. Schoen (1992) Causes of Death: Life Tables for National Population (Seminar Press, NY)
A. Madison (1982) Phases of Capitalist Development (Oxford University Press, NY)
A. Sen (1999) Development as Freedom (Knopf, NY)


What caused life expectancy to *increase* even when GDP was *negative* ?
8
6
4
2
0
-2
4
6.5
2.4
1.4
6.8
2.8
0.06
-0.1
0.16
0.35
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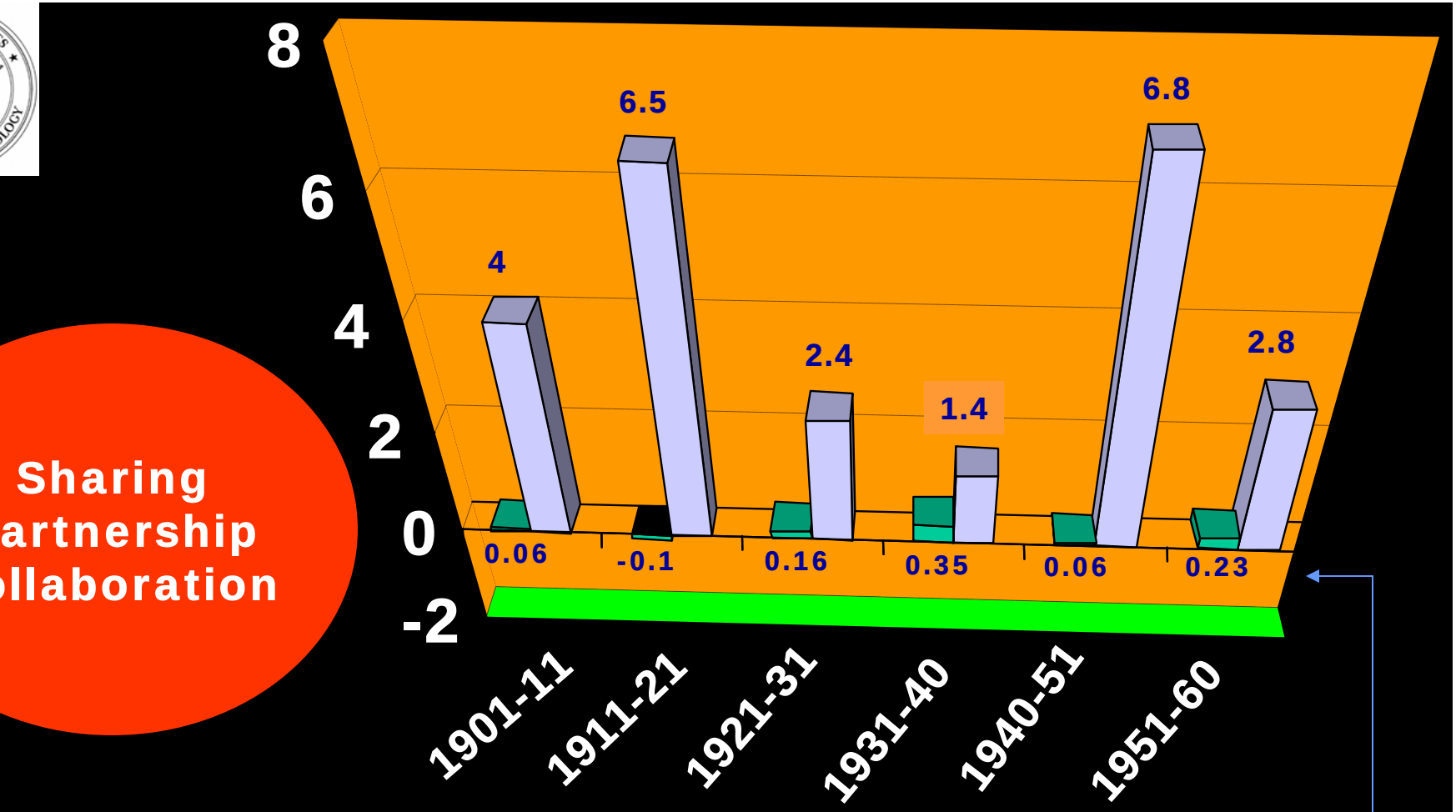
1951-60
GDP
Percentage Decadal Growth of GDP Per Capita in UK
Longevity
Decadal Increases in Life Expectancy at Birth in England & Wales (Improvement in Years)

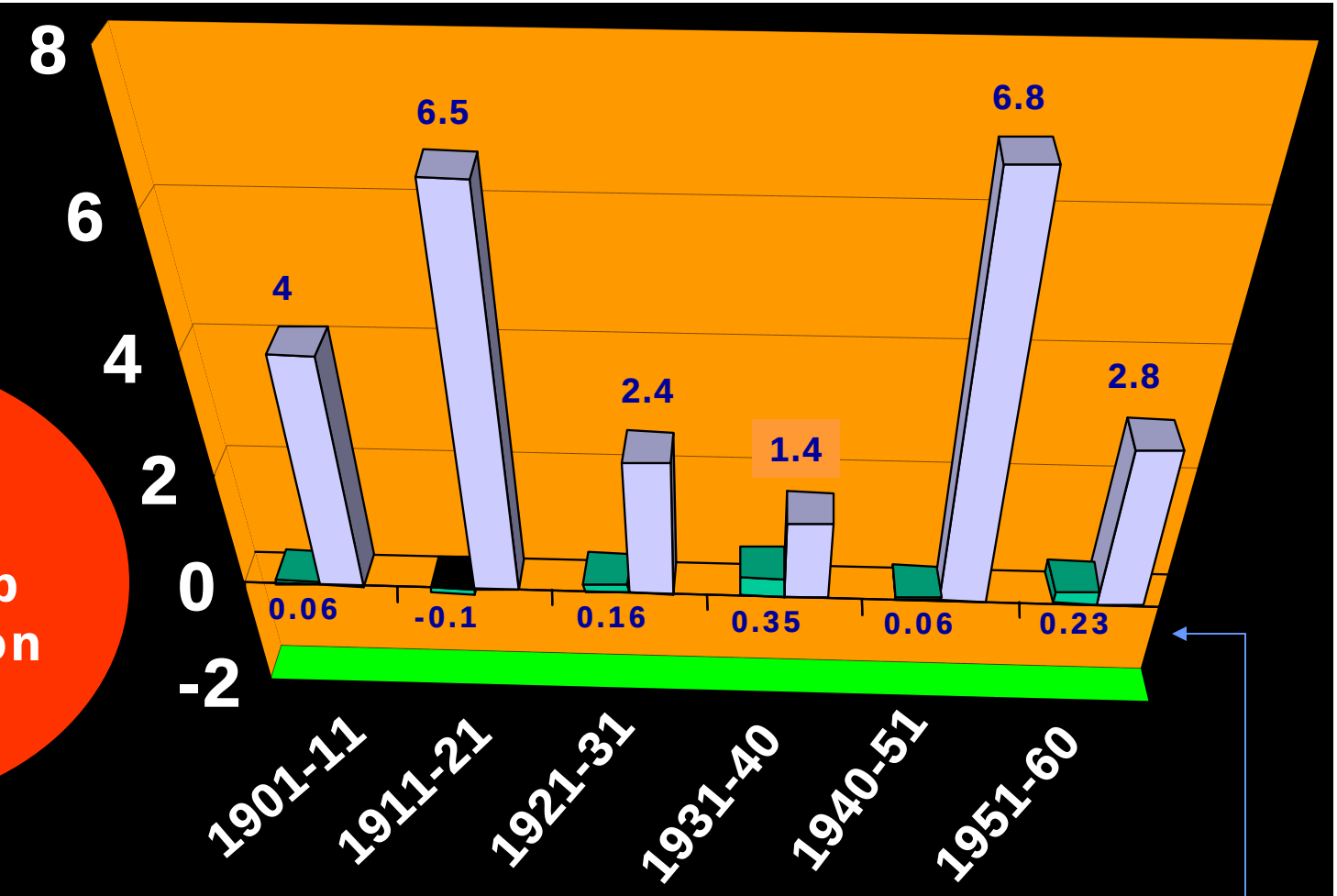
Sharing
Partnership
Collaboration



GDP — Percentage Decadal Growth of GDP Per Capita in UK

Longevity — Decadal Increases in Life Expectancy at Birth in England & Wales (Improvement in Years)

Sharing
Partnership
Collaboration



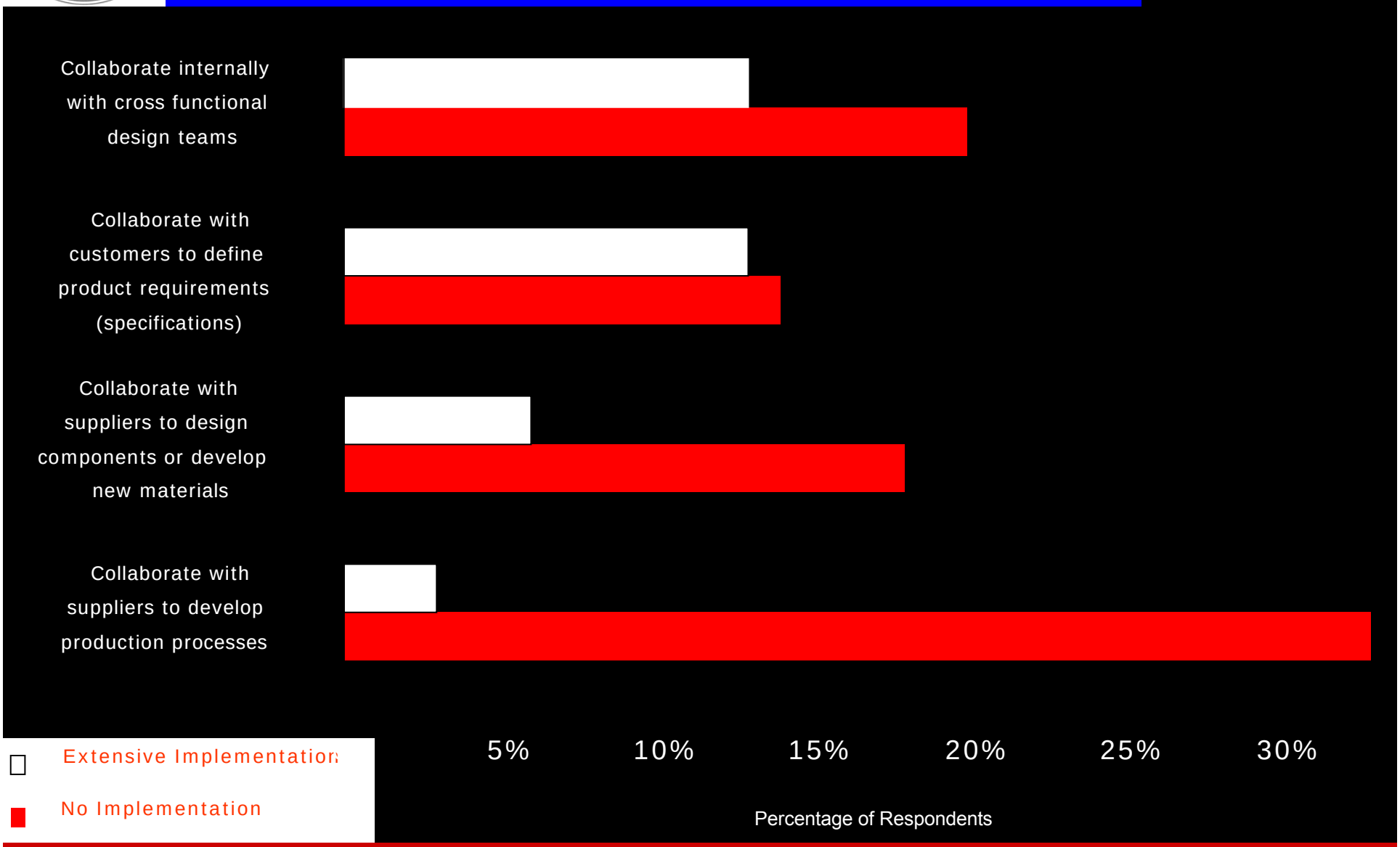
GDP — Percentage Decadal Growth of GDP Per Capita in UK

Longevity — Decadal Increases in Life Expectancy at Birth in England & Wales (Improvement in Years)

AMARTYA SEN > NOBEL PRIZE IN ECONOMICS, 1998

Trend: Lack of Collaboration

Source: Deloitte Research

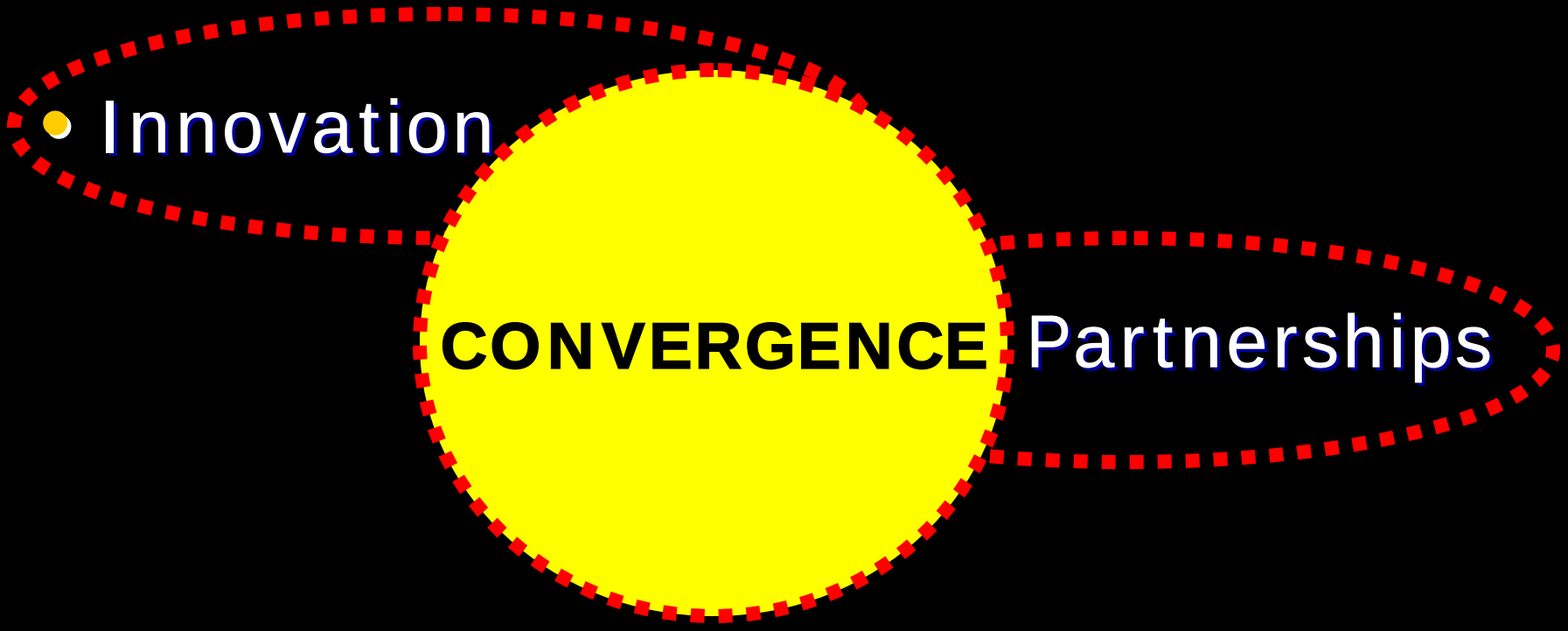


DRIVERS: Sustainable Economic Growth

- Innovation

Partnerships

DRIVERS: Sustainable Economic Growth



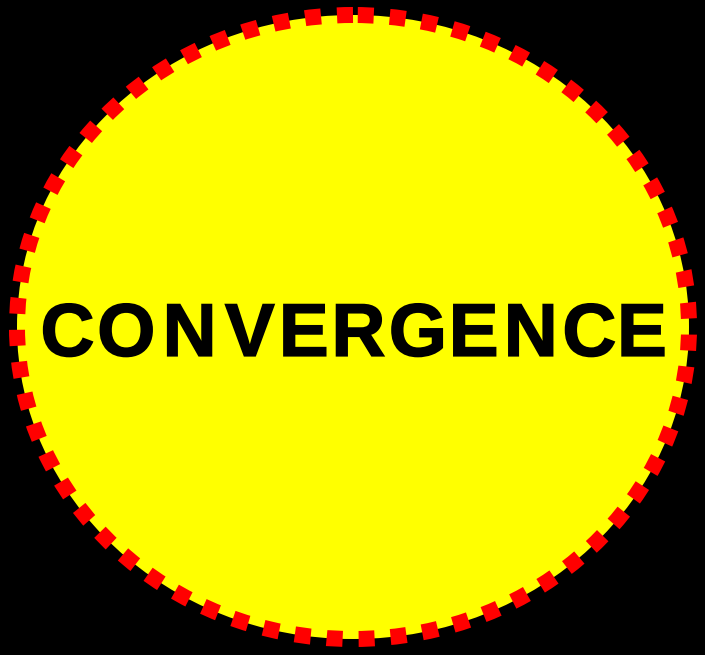
Economic Growth

Transistors

IC

Microprocessors

Computers



Economic Growth

Transistors

IC

Microprocessors

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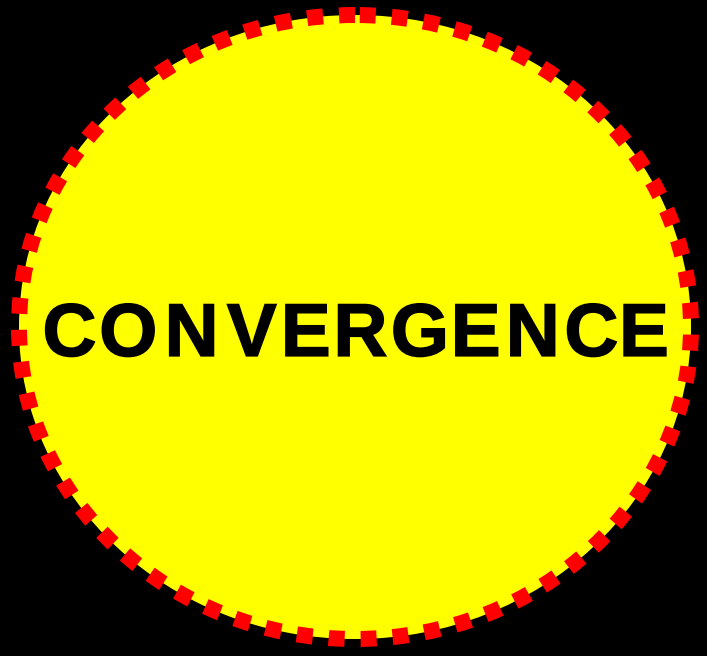


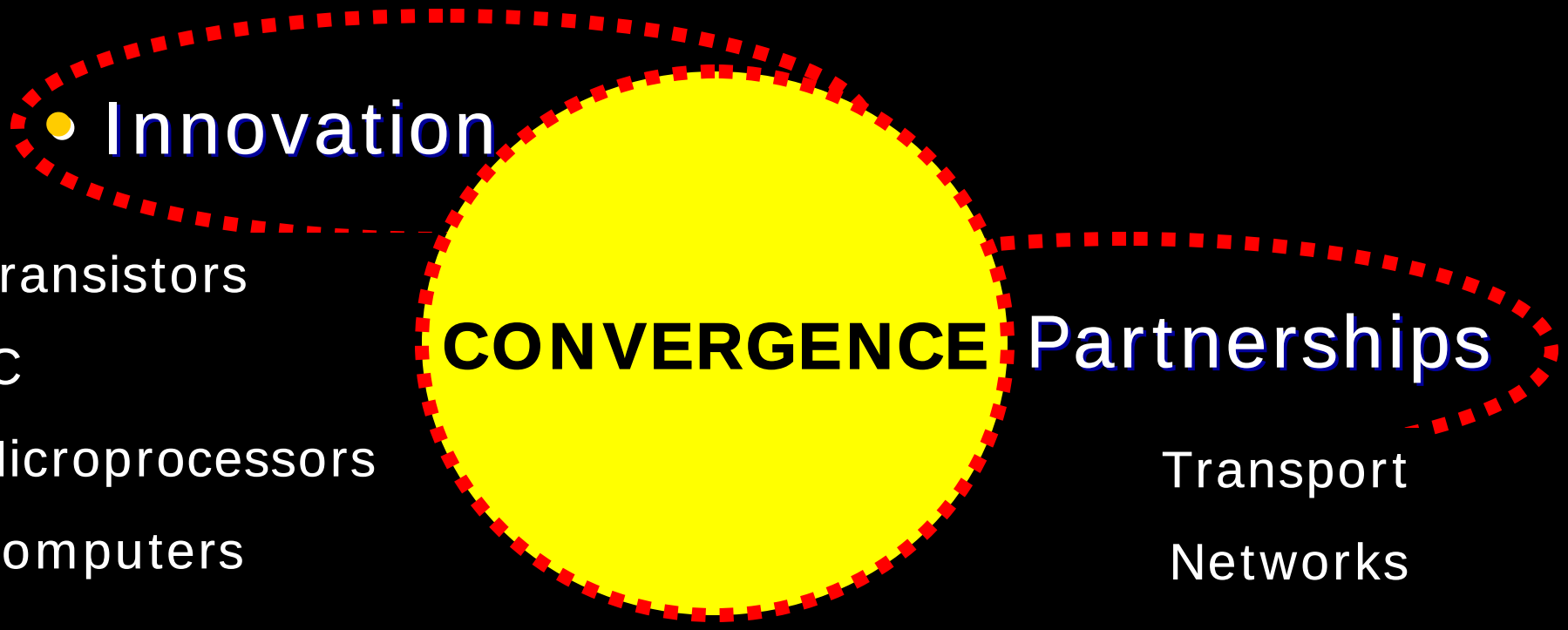
Transport

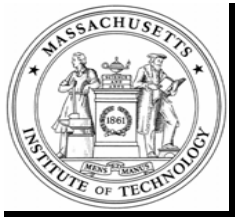
Networks

Credit Cards

Auctions

Economic Growth





eBay

Innovation

Transistors

IC

Microprocessors

Computers

CONVERGENCE

Partnerships

Transport

Networks

Credit Cards

Auctions

Can Convergence of Innovation Catalyse Economic Growth ?

Can Convergence of Innovation Catalyse Economic Growth ?

Teachers → Students → Faculty

Can Convergence of Innovation Catalyse Economic Growth ?

Teachers → Students → Faculty

Research → University → Global Collaboration

Can Convergence of Innovation Catalyse Economic Growth ?

Teachers → Students → Faculty

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School + University + Incubators + Industry = Cluster

Can Convergence of Innovation Catalyse Economic Growth ?

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School + University + Incubators + Industry = Cluster

Invention + Innovation + Translation + Capital = Vision

Can Convergence of Innovation Catalyse Economic Growth ?

Teachers → Students → Faculty

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School + University + Incubators + Industry = Cluster

Invention + Innovation + Translation + Capital = Vision

New Paradigm Shifts + New Markets → Economic Growth

Can Convergence of Innovation Catalyse Economic Growth ?

Likely

All Advantages Are Temporary !

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- Medicine and Healthcare
- Environment
- Logistics
- Energy
- ICT

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

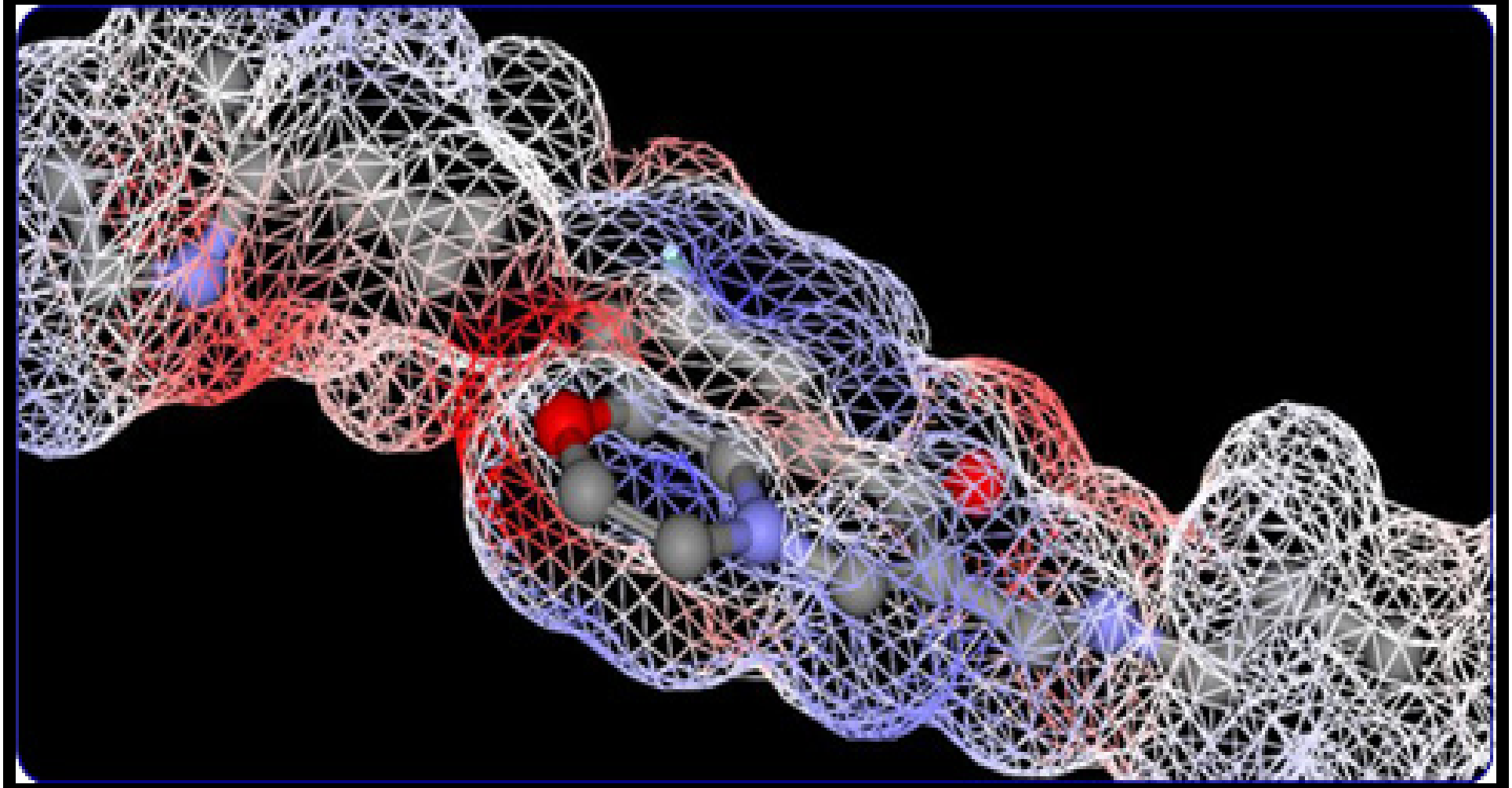
- Medicine and Healthcare

Pharma The next big bang?

Drug	Manufacturer	Treatment	Sales to Jun 2007
Lipitor	Pfizer	Hypercholesterolemia	**$ 13.5 billion**
Nexium	AstraZeneca	Acid reflux, ulcers	**$ 6.9 billion**
Seretide	GlaxoSmithKline	Asthma	**$ 6.7 billion**
Plavix	Bristol-Myers Squibb	Atherosclerosis	**$ 5.8 billion**
Aranesp	Amgen	Anemia	**$ 5.1 billion**
Enbrel	Amgen	Rheumatoid arthritis	**$ 4.9 billion**
Zyprexa	Eli Lilly	Schizophrenia	**$ 4.9 billion**
Risperdal	J & J	Schizophrenia	**$ 4.8 billion**
Norvasc	Pfizer	Hypertension	**$ 4.5 billion**
Seroquel	AstraZeneca	Schizophrenia	**$ 4.2 billion**
Avastin	Genentech	Cancer (liver, colon)	**$ 2.3 billion**

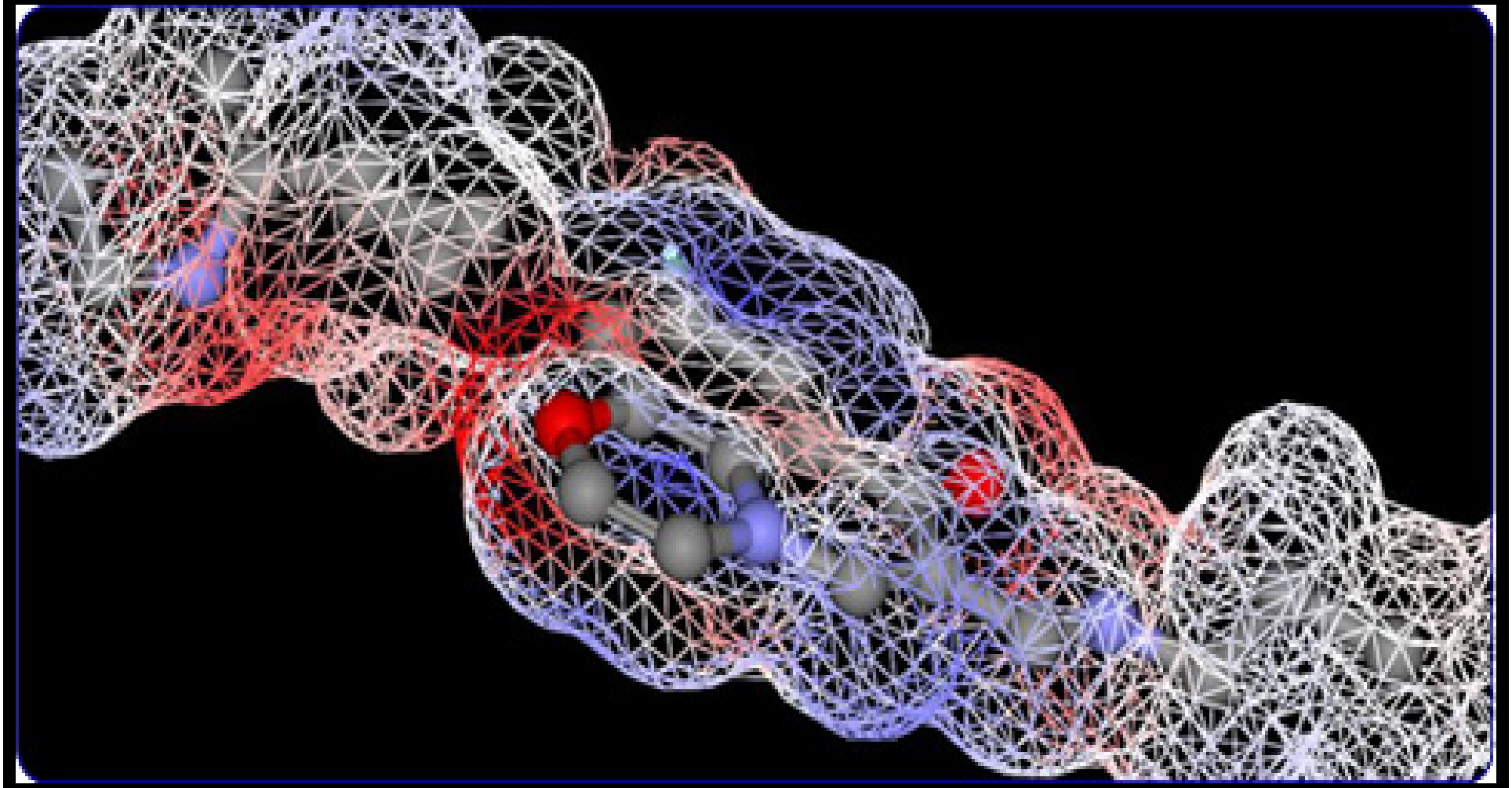
Synthetic Organic Chemistry

Synthetic Organic Chemistry



Source: www.cylenepharma.com

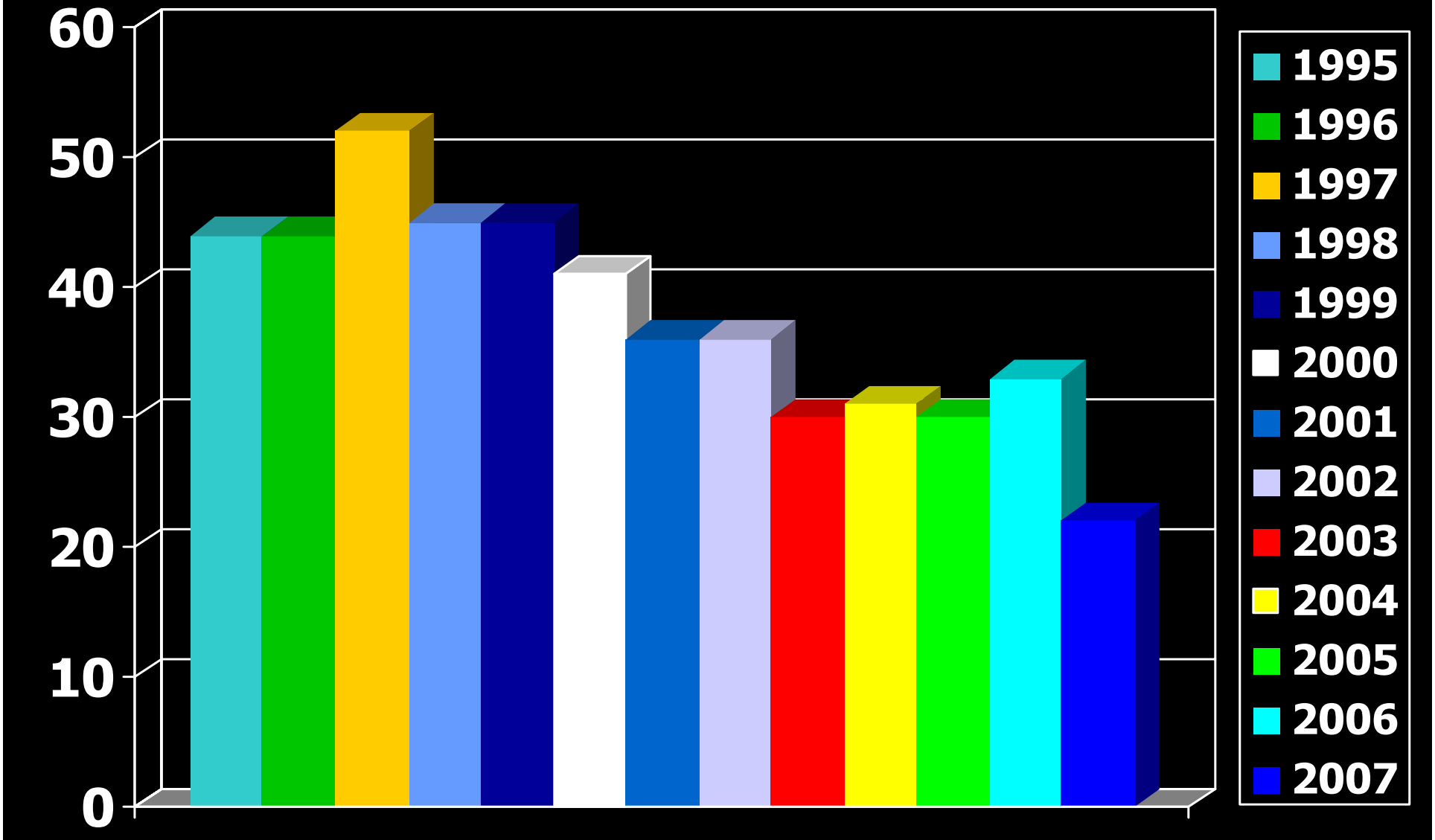
Synthetic Organic Chemistry: Designer Molecules



Quarfloxin (CX-3543) is a fluoroquinolone.
Rationally designed to selectively inhibit ribosomal RNA.

Source: IMS

Decreasing Number of New Drugs



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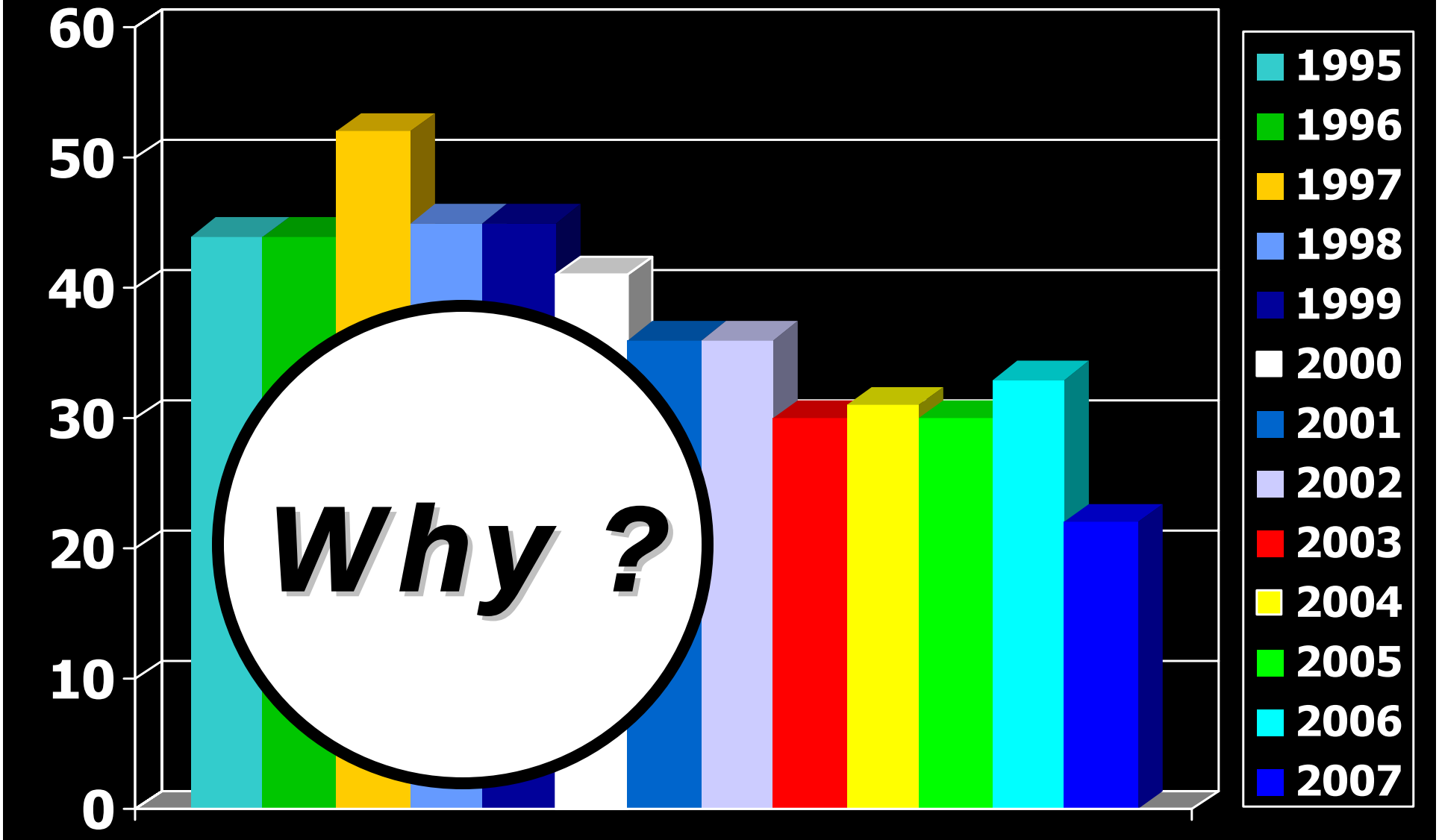
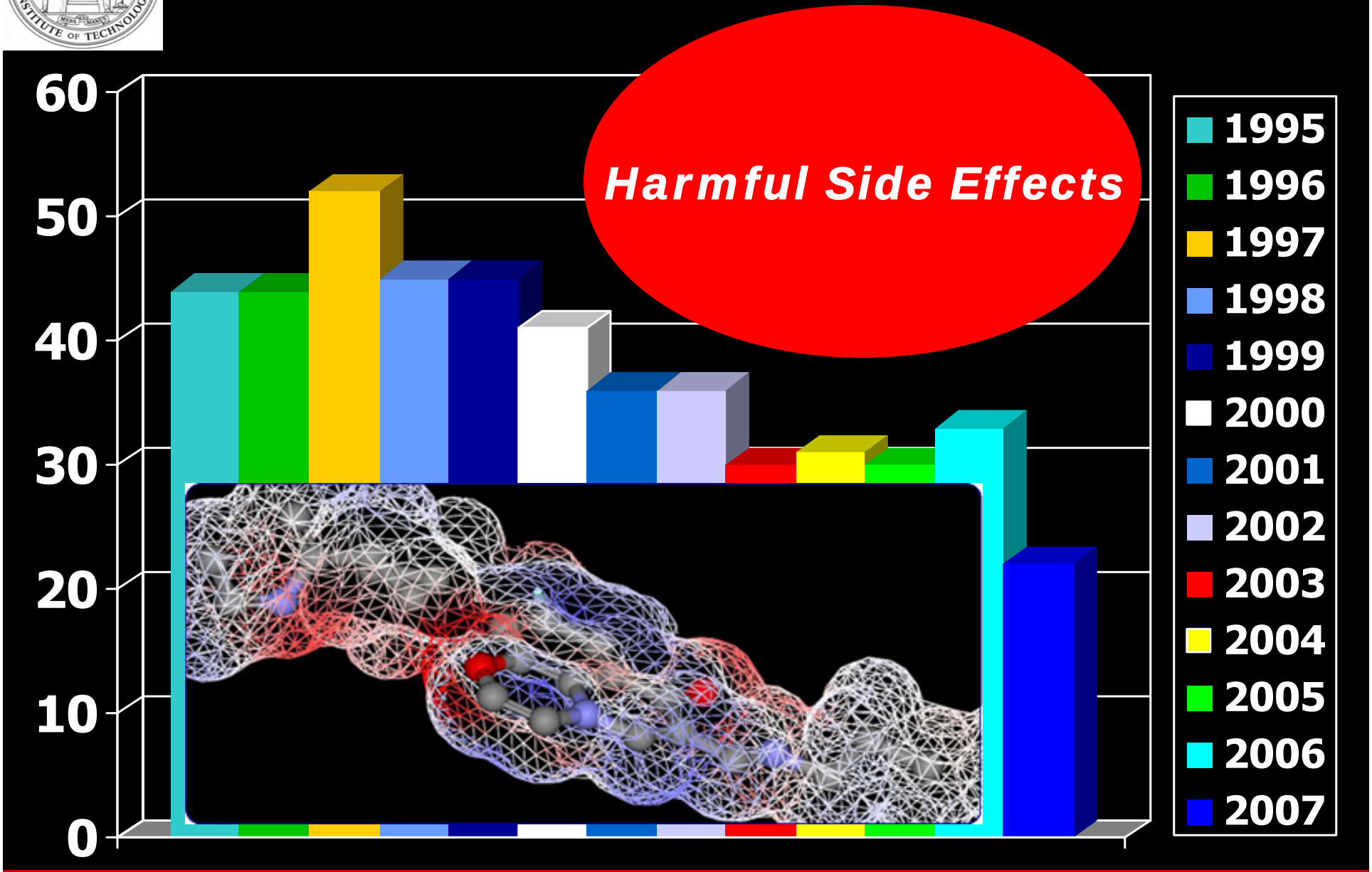
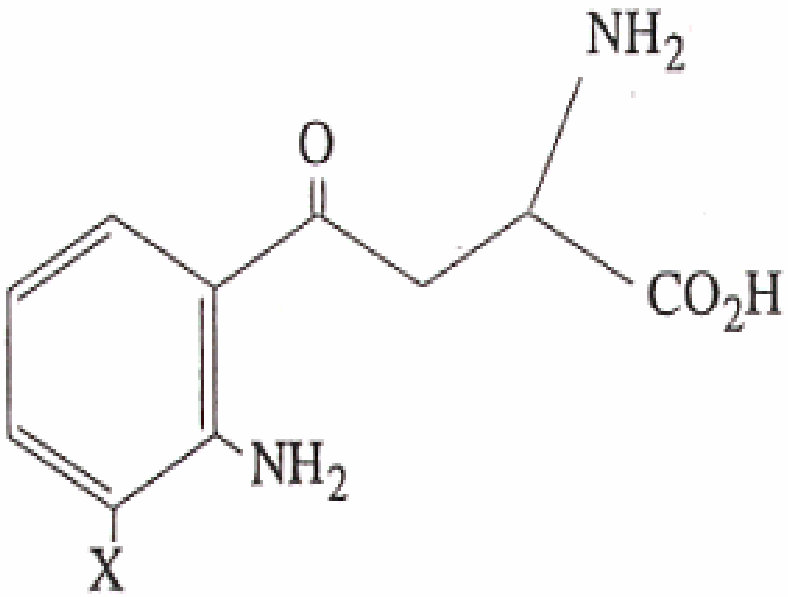


Synthetic Organic Chemistry: Designer Molecules



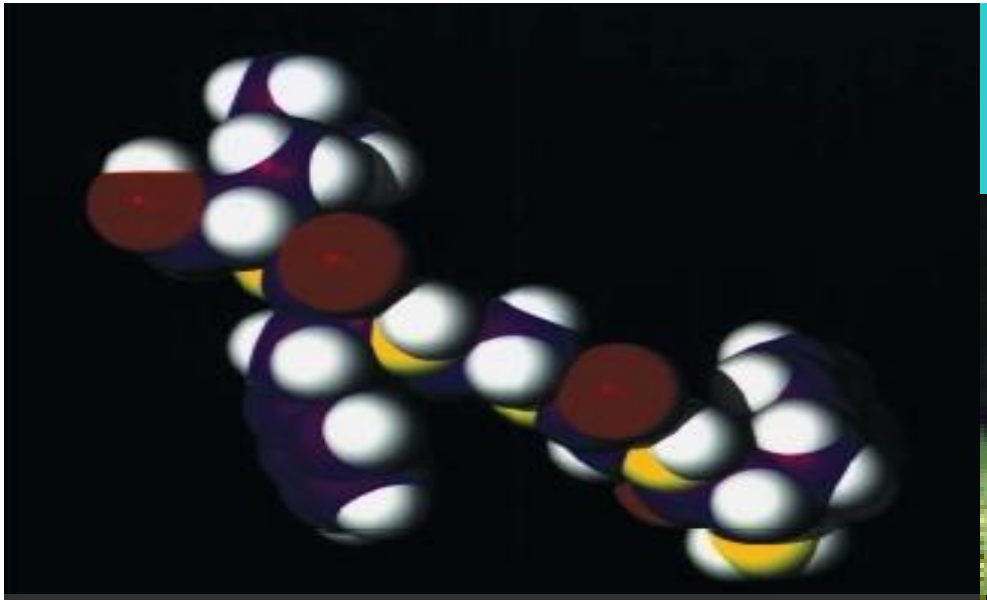
in vivo

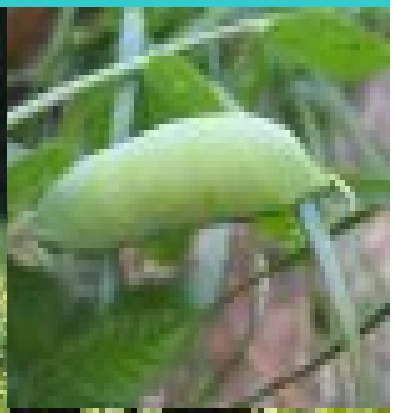
Biologics

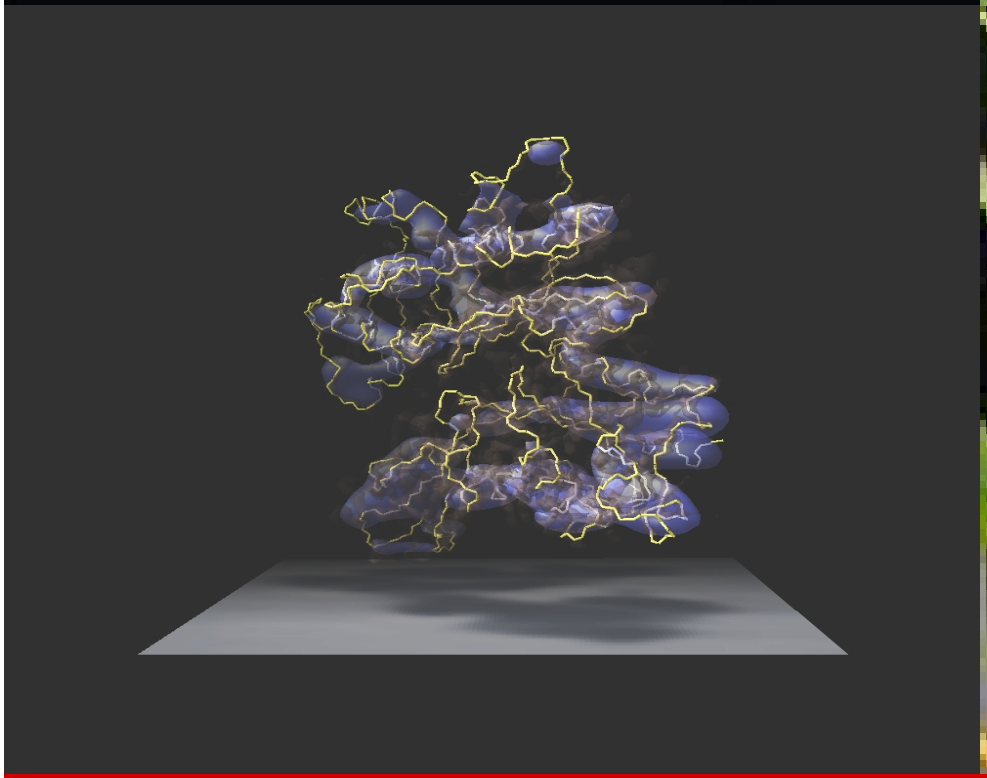


Synthetic Chemistry

Biologics







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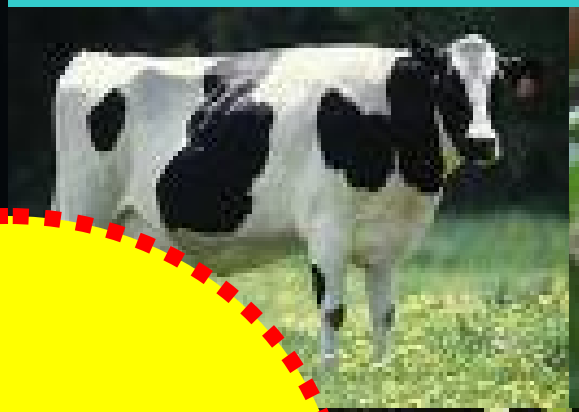
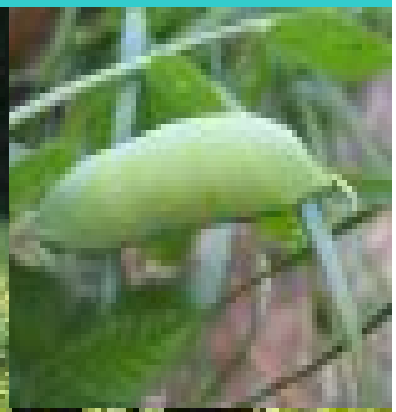
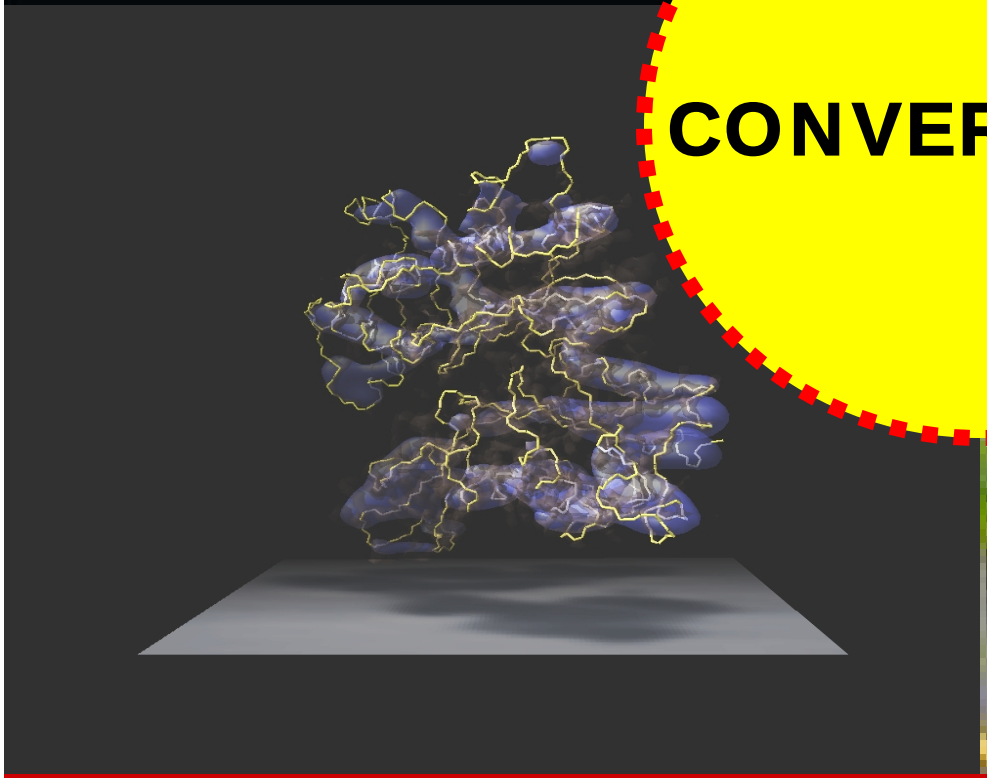




CONVERGENCE



Case: VAD-dependent Xerophthalmia

In sub-Saharan Africa, more than 3 million children, under 5 years of age, suffer from Vitamin A deficiency (VAD) leading to xeropthalmia, the primary cause of childhood blindness.

Source: Nuffield Foundation

Case: VAD-dependent Xerophthalmia

Benefit: Prevention of Blindness

In sub-Saharan Africa, more than 3 million children, under 5 years of age, suffer from Vitamin A deficiency (VAD) leading to xeropthalmia, the primary cause of childhood blindness.

In developing economies, 300 million children have sub-clinical deficiency of Vitamin A, greatly increasing their risk of contracting infectious diseases.

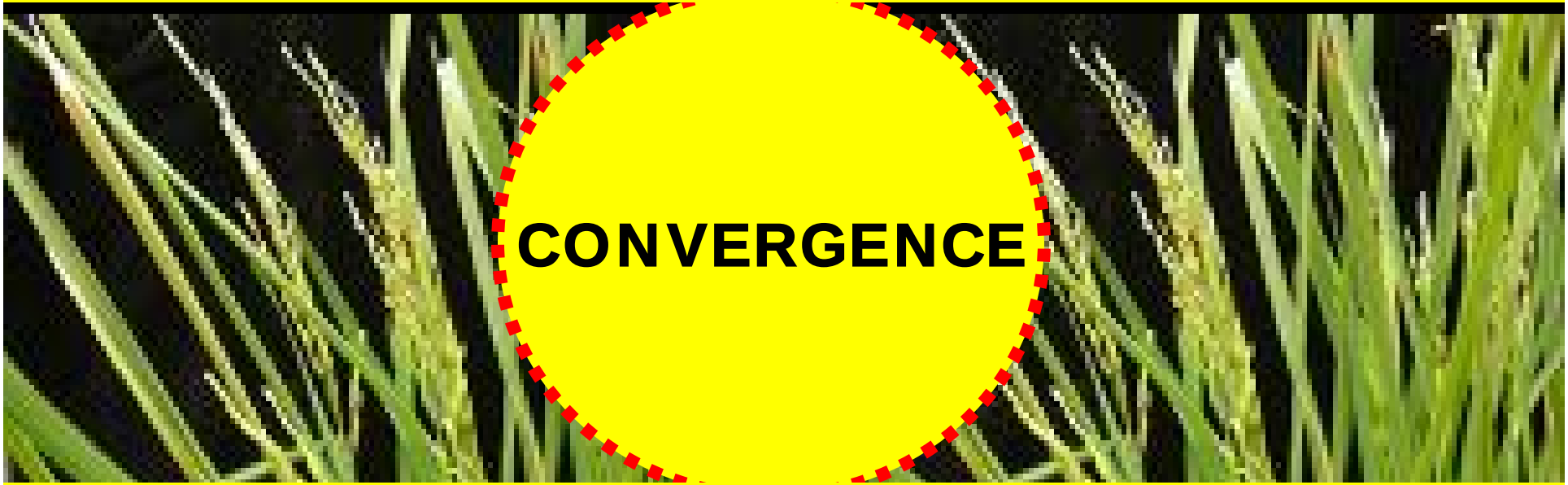
Case: VAD-dependent Xerophthalmia

Benefit: Prevention of Blindness

Solution: β-Carotene in Staple Food (Rice)

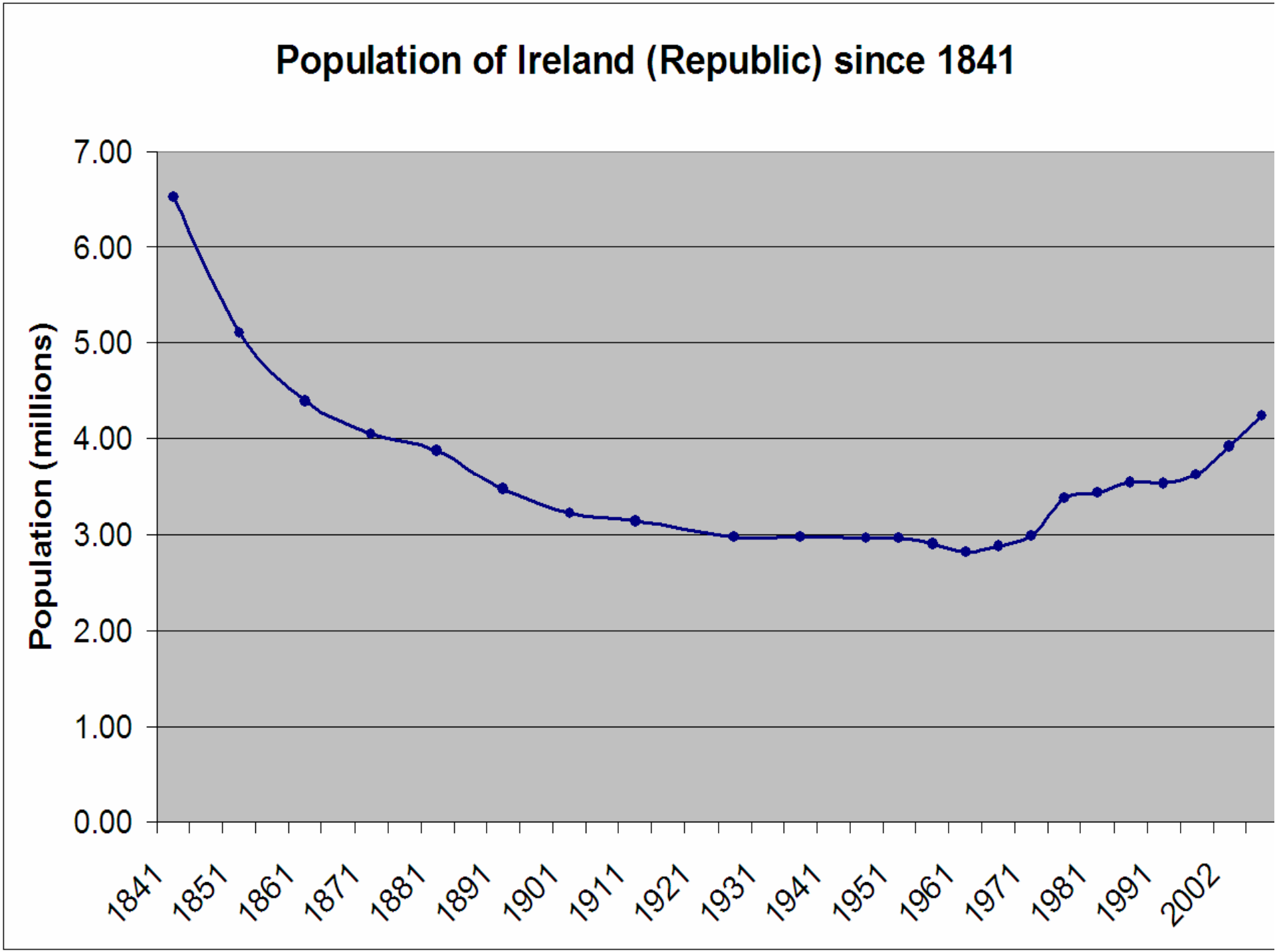
Rice has been modified to contain a precursor of Vitamin A.

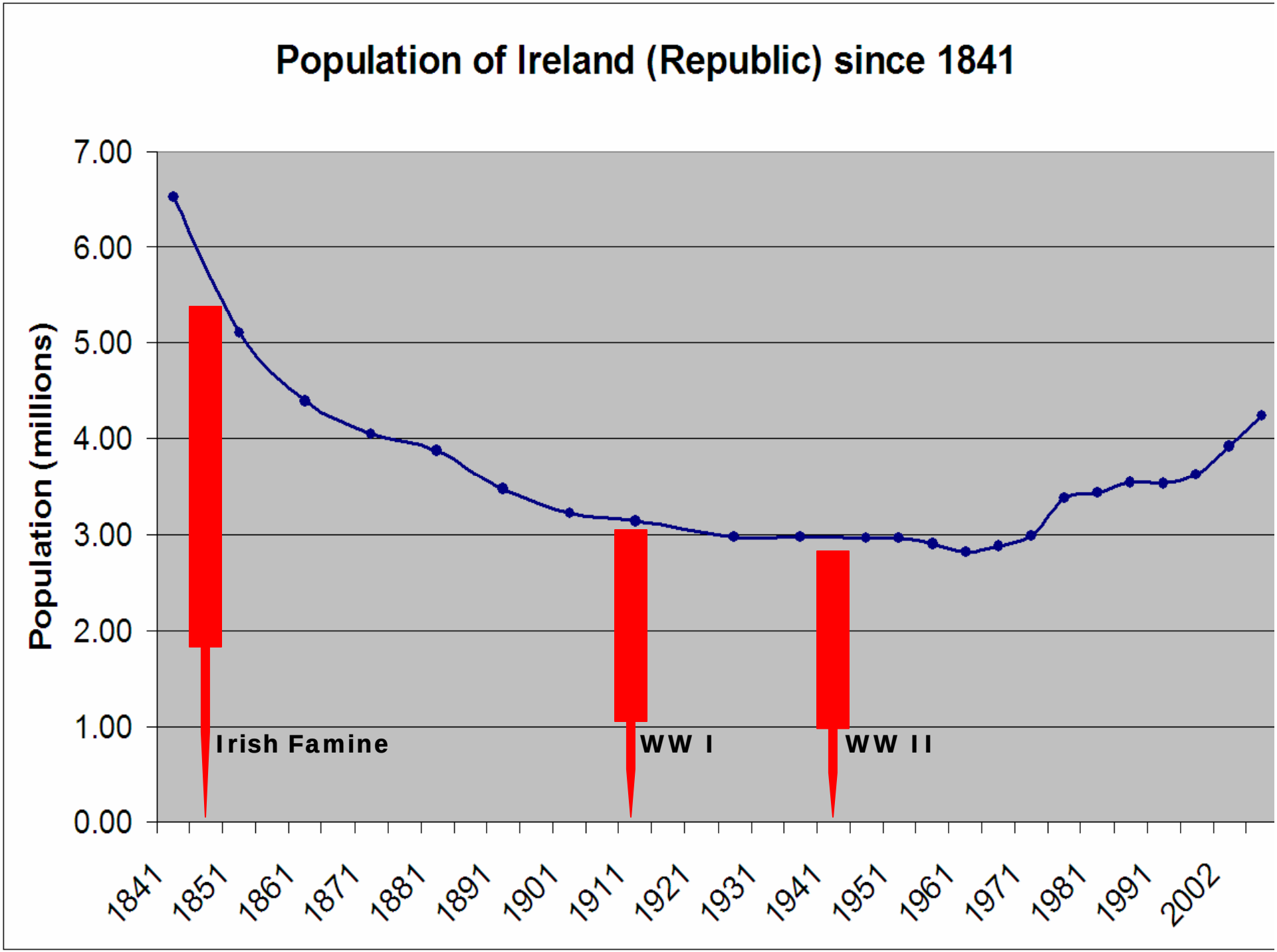
A bacterial gene together with two genes from daffodils have been inserted



into an edible strain of rice to synthesize the micro-nutrient β-carotene

which is converted into Vitamin A in the body.


Population of Ireland (Republic) since 1841
Population (millions)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1841
1851
1861
1871
1881
1891
1901
1911
1921
1931
1941
1951
1961
1971
1981
1991
2002


Population of Ireland (Republic) since 1841
Population (millions)
7.00
6.00
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3.00
2.00
1.00
0.00
Irish Famine
WW I
WW II
1841
1851
1861
1871
1881
1891
1901
1911
1921
1931
1941
1951
1961
1971
1981
1991
2002

Population of Ireland (Republic)

Population (millions)

7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00

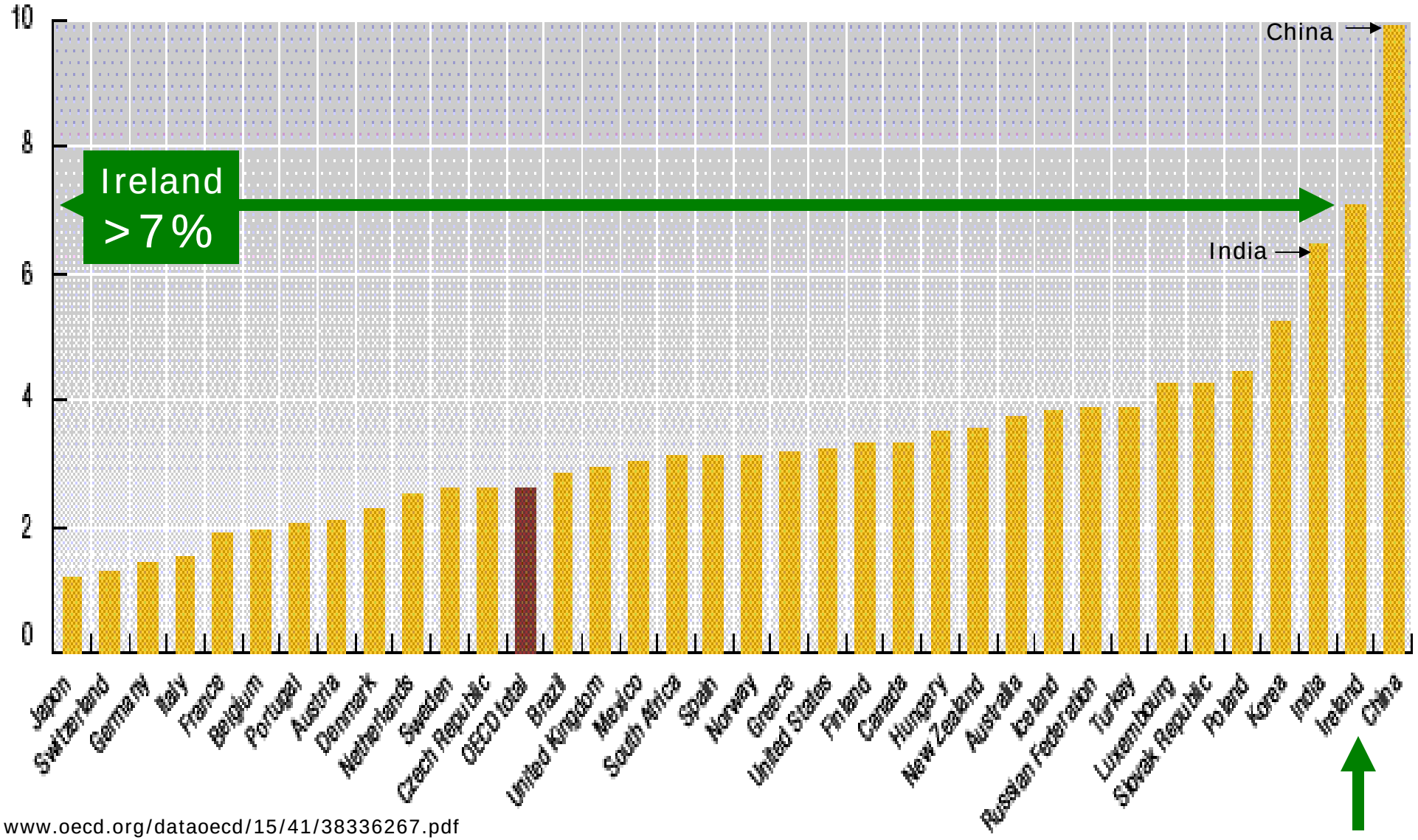
Irish Famine

WW I

WW II

1841 1851 1861 1871 1881 1891 1901 1911 1921 1931 1941 1951 1961 1971 1981 1991 2002

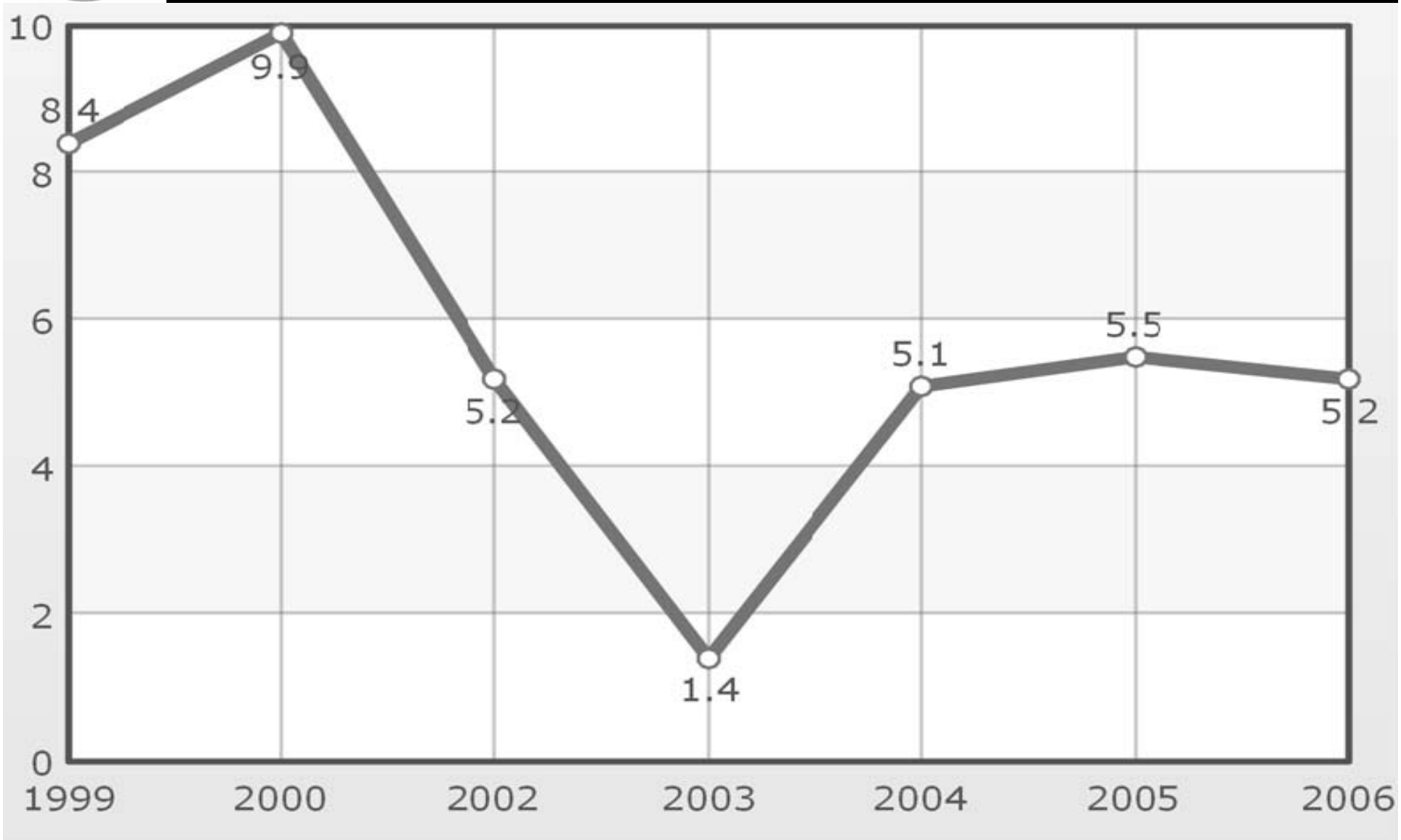
Average Annual Real GDP Growth 1992-2005



www.oecd.org/dataoecd/15/41/38336267.pdf

Source: CIA World Factbook

Ireland - GDP - real growth rate (%)

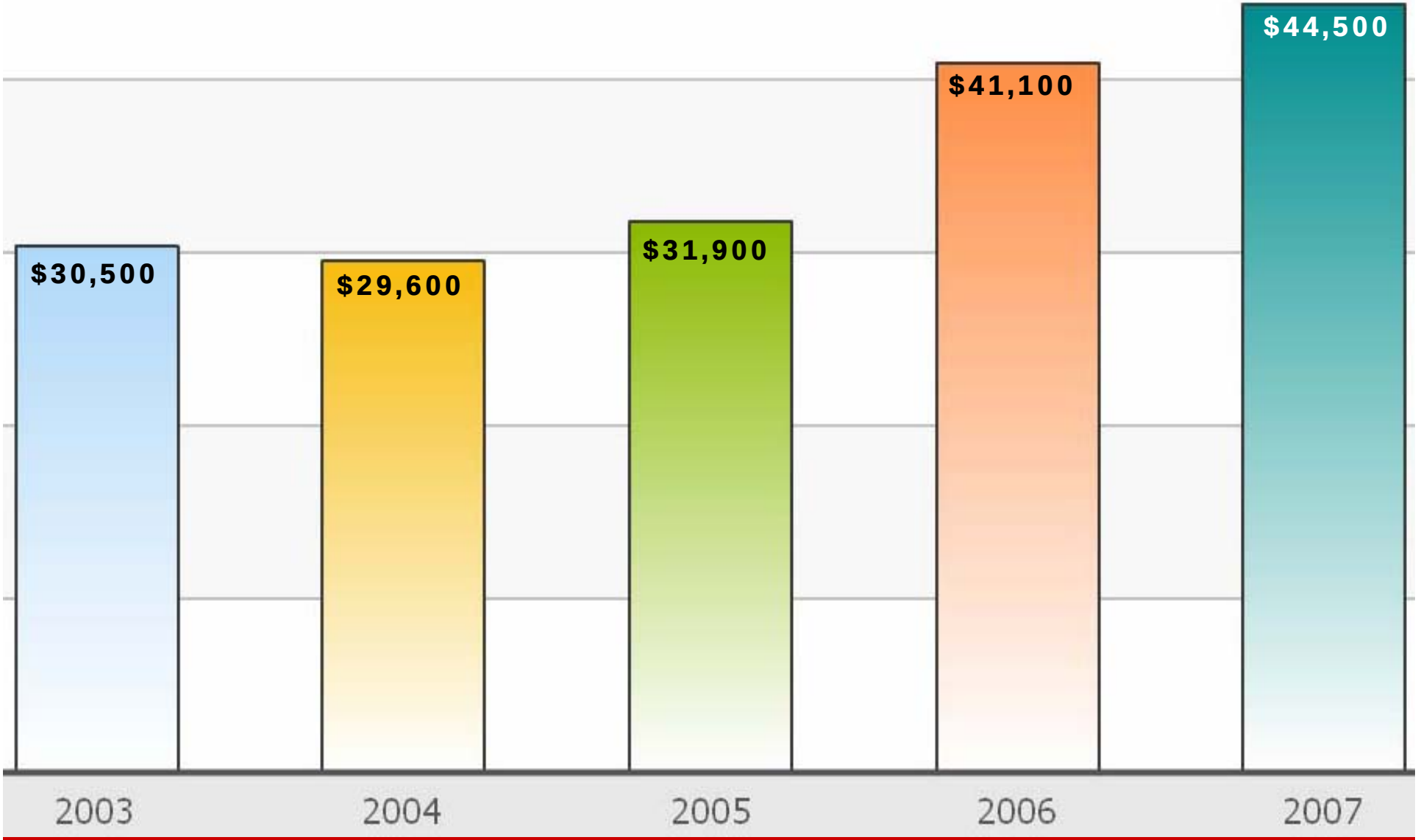


Source: CIA World Factbook

Ireland GDP (Purchasing Power Parity)

Source: CIA World Factbook

Ireland GDP Per Capita (Purchasing Power Parity)

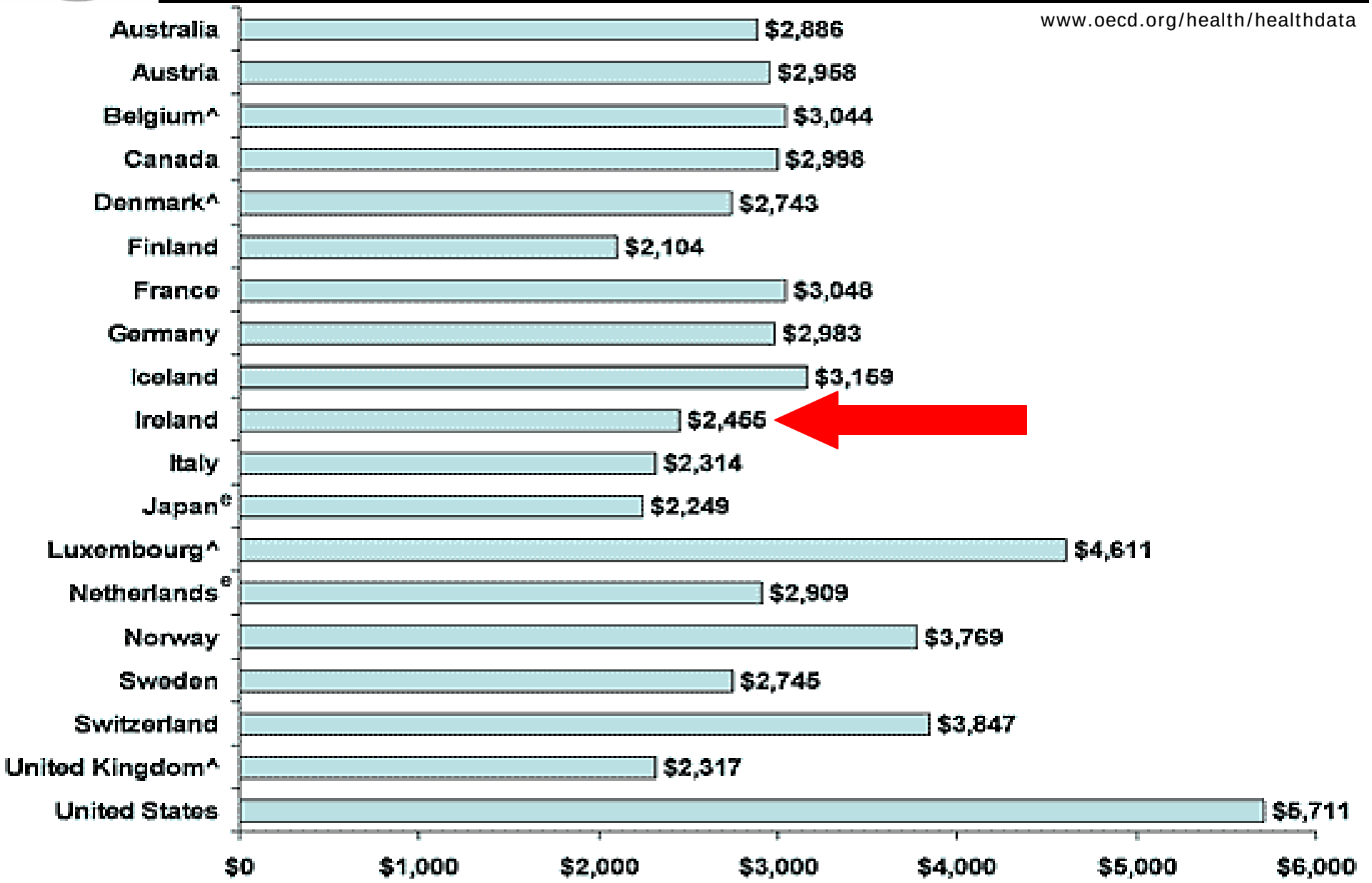


Total Health Expenditures Per Capita

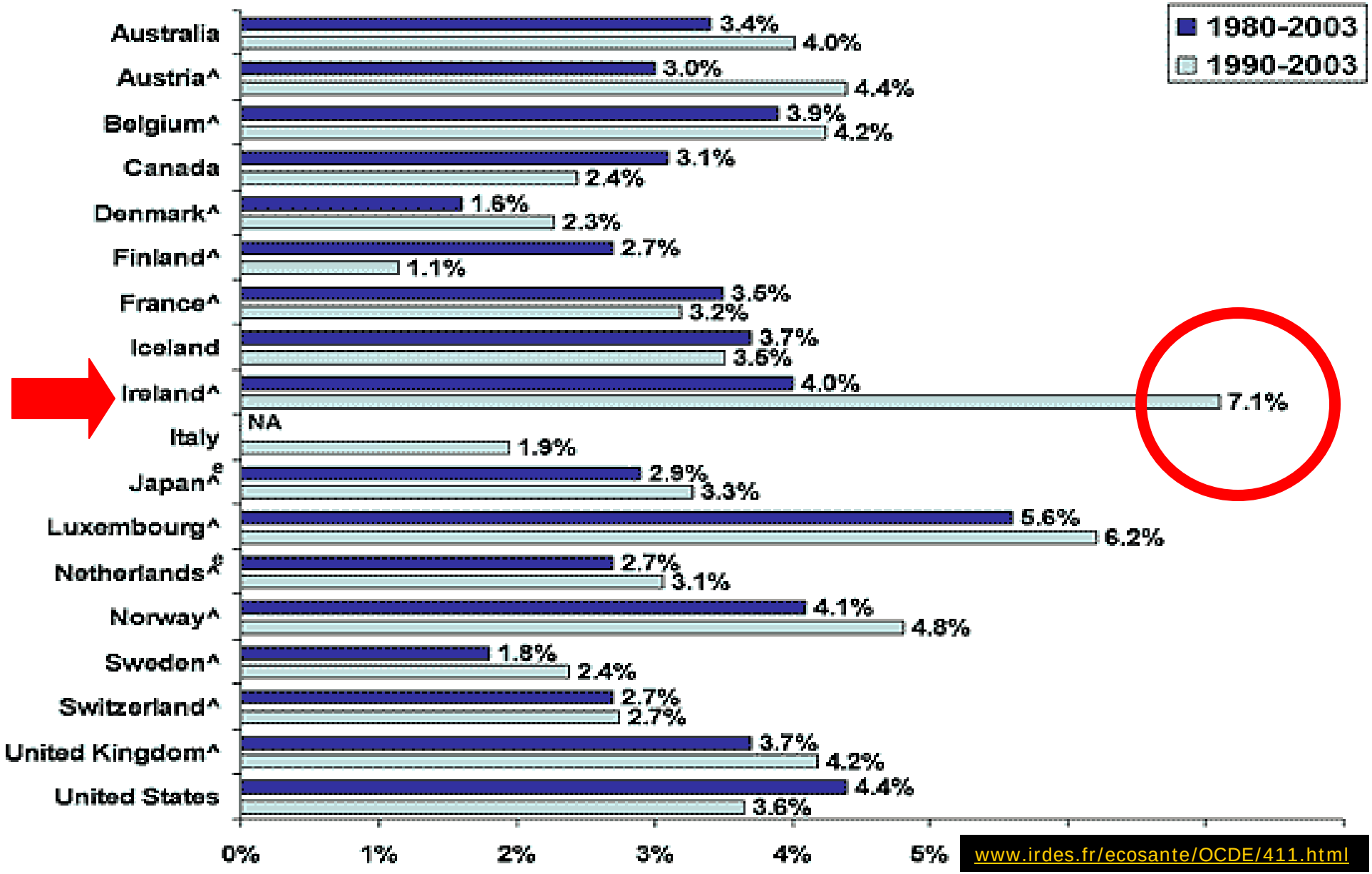
www.oecd.org/health/healthdata	1970	1980	1990	2003
Australia	$252*	$691	$1,306	$2,886
Austria	193	770	1,328	2,958
Belgium	148	636	1,341	3,044^
Canada	299	783	1,737	2,998
Denmark	384*	927	1,522	2,743^
Finland	191	590	1,419	2,104
France	205	697	1,532	3,048
Iceland	163	703	1,593	3,159
Ireland	117	519	794	2,455
Italy	NA	NA	1,387	2,314
Japan	149	580	1,116	2,249[e]
Luxembourg	163	640	1,533	4,611^
Netherlands	NA	755	1,435	2,909[e]
Norway	141	665	1,393	3,769
Sweden	312	944	1,589	2,745
Switzerland	351	1,031	2,029	3,847
United Kingdom	163	480	987	2,317^
United States	352	1,072	2,752	5,711

Per Capita Healthcare Expenditure, 2003

www.oecd.org/health/healthdata

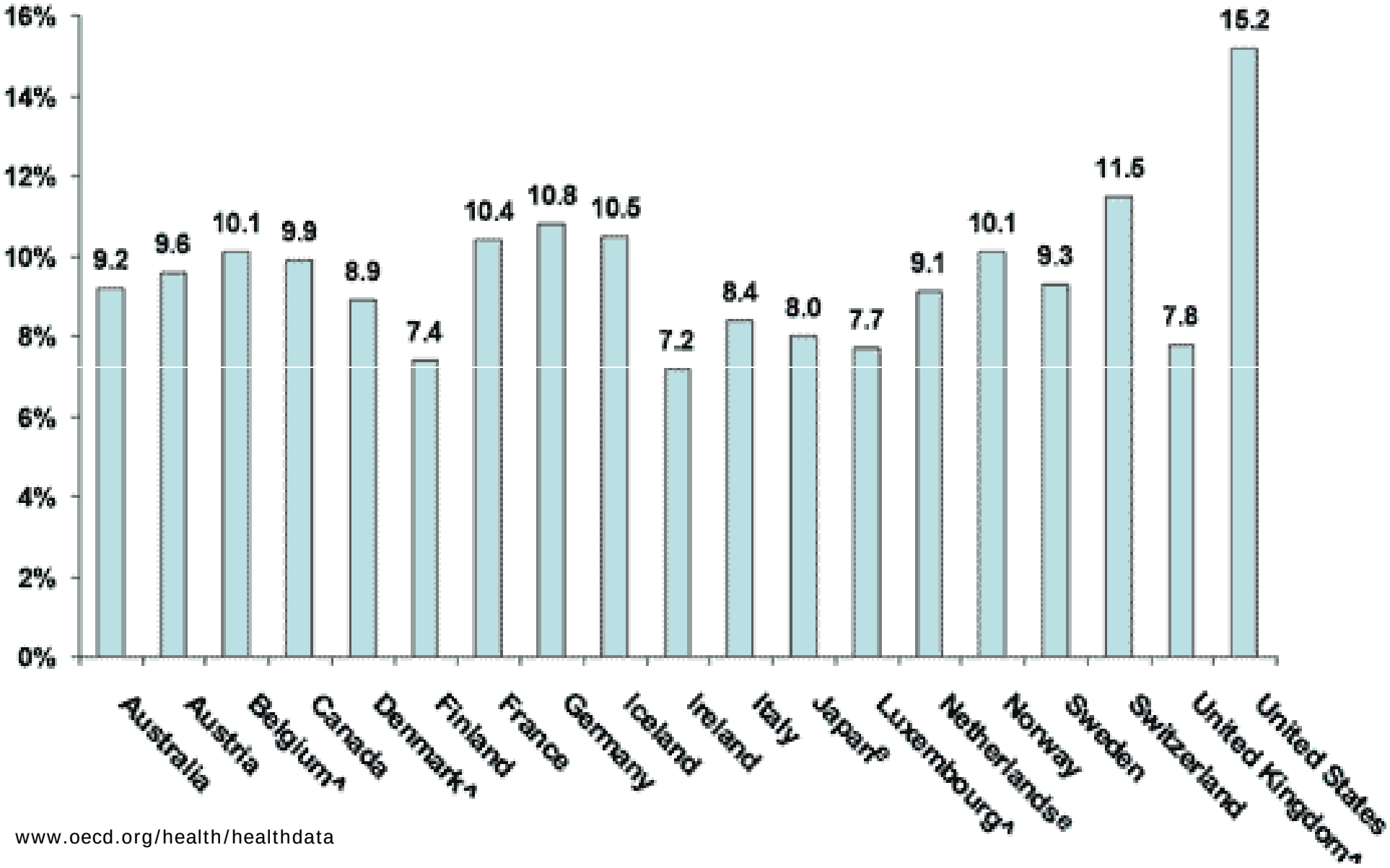


Average Annual Growth Rate
Total Health Expenditures Per Capita



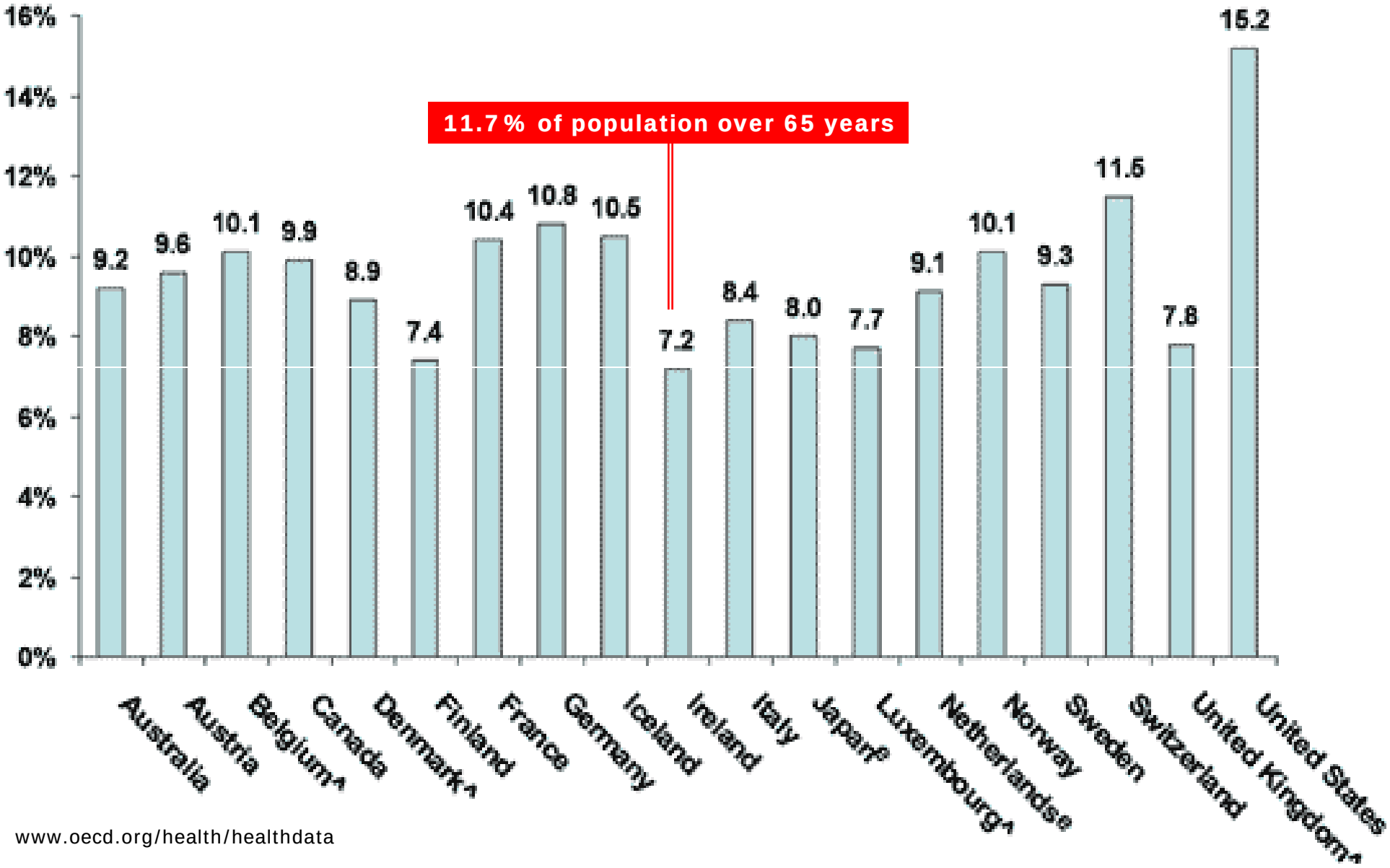
www.irdes.fr/ecosante/OCDE/411.html

Total Health Expenditures as a Share of GDP, 2003



www.oecd.org/health/healthdata

Total Health Expenditures as a Share of GDP, 2003



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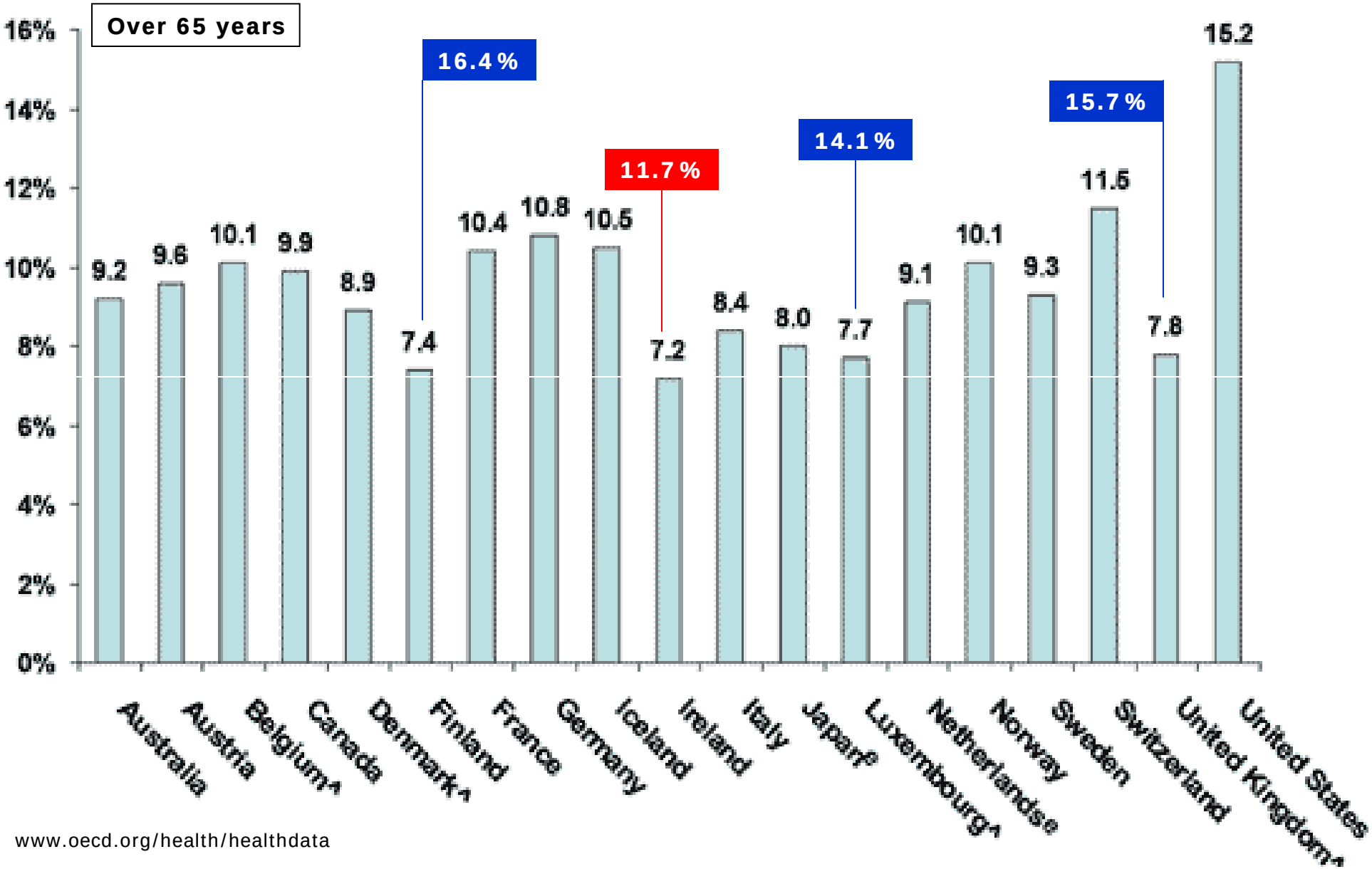

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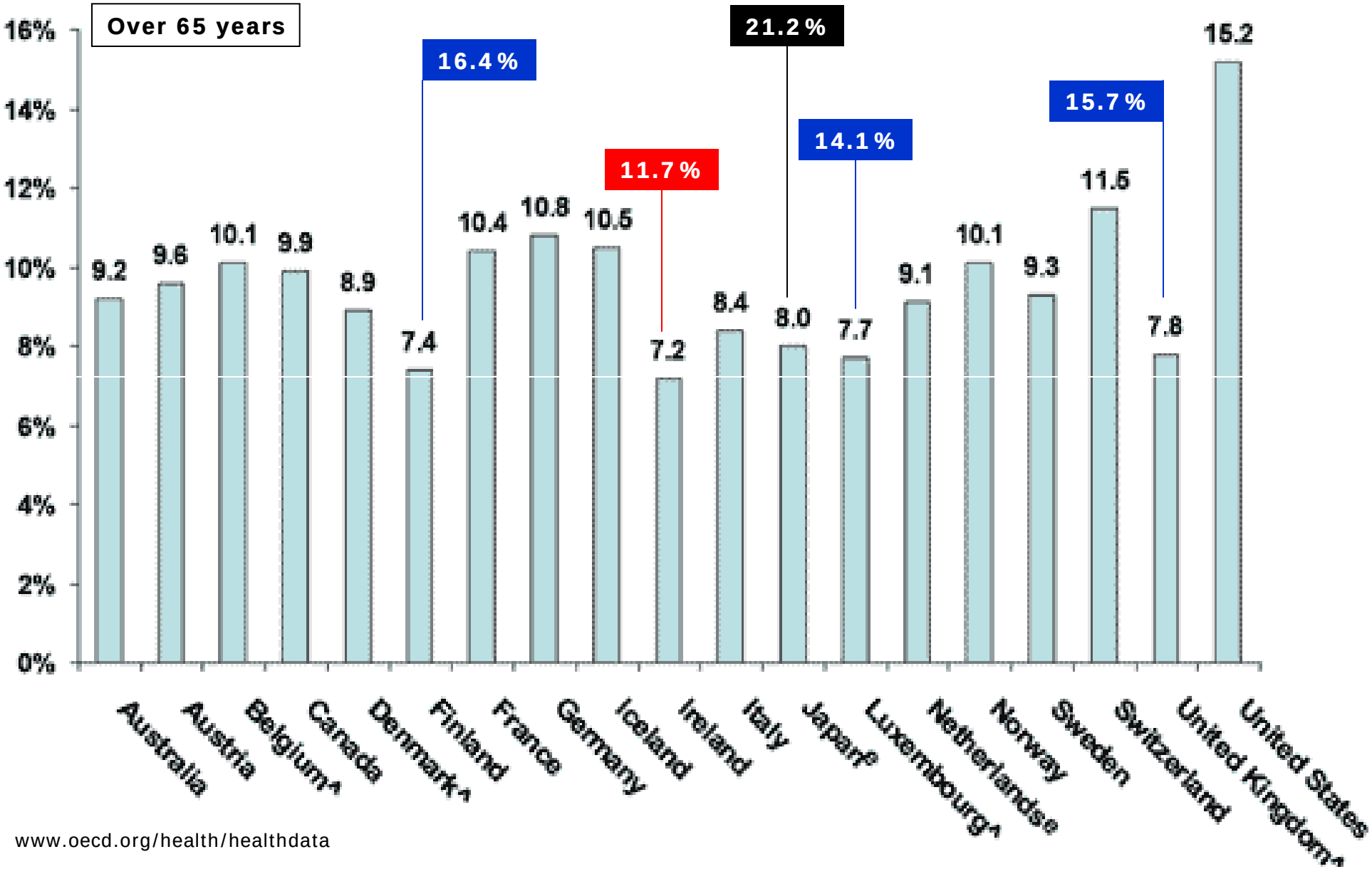

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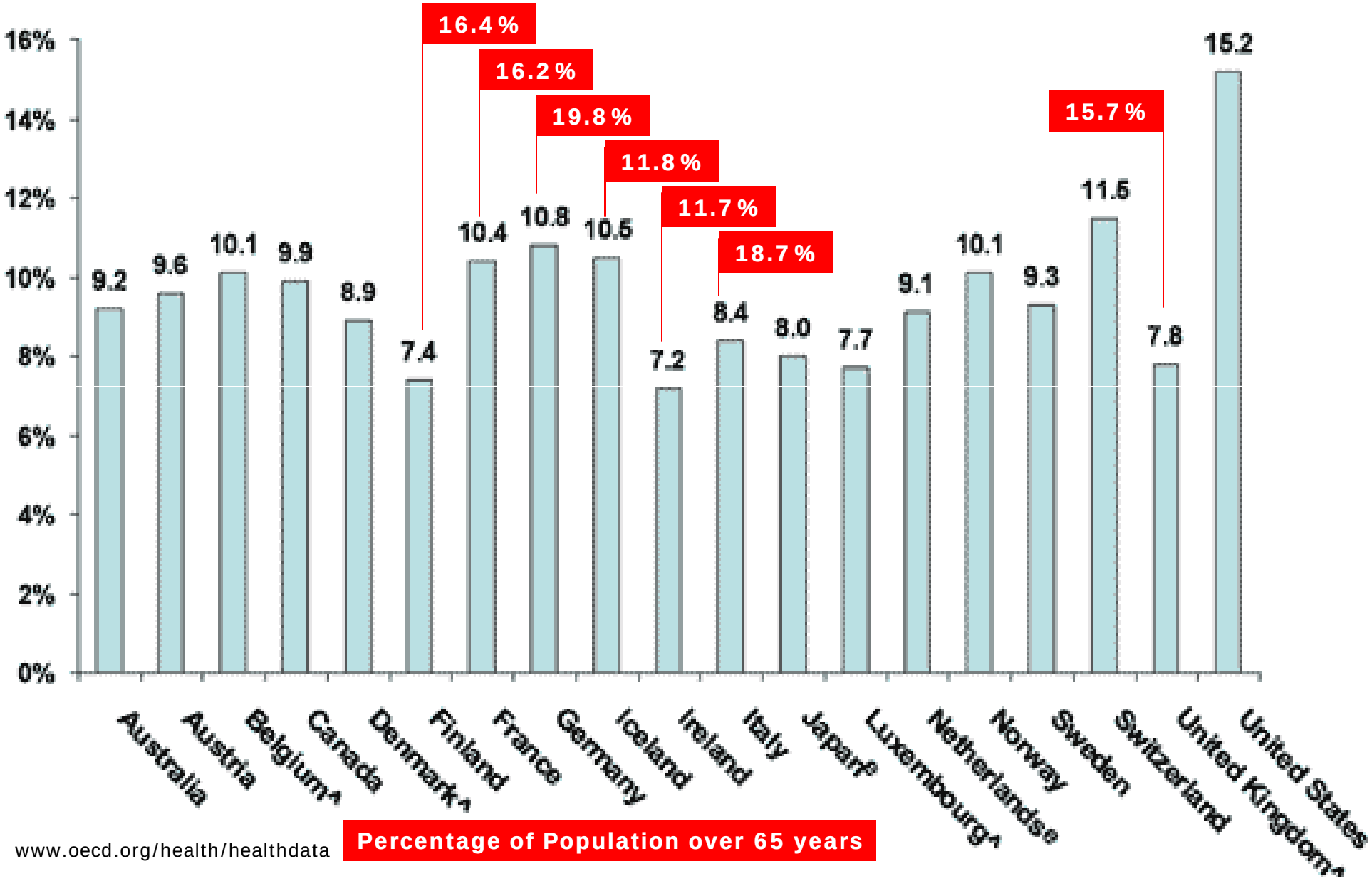

www.oecd.org/health/healthdata

Percentage of Population over 65 years

Ireland 2006

Age Group	Males	Females	Persons
0-14	443,044	421,405	864,449
15-24	321,007	311,725	632,732
25-44	681,988	663,885	1,345,873
45-64	468,037	460,831	928,868
65 years +	207,095	260,831	467,926
Total	**2,121,171**	**2,118,677**	**4,239,848**

Source: Central Statistics Office, Cork

Ireland Age Demographic Distribution

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Potentially 1.4 million individuals may require healthcare attention

Source: Central Statistics Office, Cork

Irish Healthcare: Key Infrastructure

Health Board Area	Number of Hospitals	Average Number of In-Patient Beds Available	In-Patients Discharge /Deaths	Average Length of Stay in Days	Average Number of Day Beds Available	Day Cases
Eastern	22	5,078	191,912	8.0	499	209,418
Midland	3	504	33,176	4.9	37	19,549
Mid-Western	6	844	46,744	5.8	67	30,528
North-Eastern	5	868	48,321	5.3	112	30,799
North-Western	3	682	36,242	5.4	59	39,933
South-Eastern	6	1,256	70,528	5.5	118	31,777
Southern	9	1,856	82,524	6.3	126	80,835
Western	5	1,289	67,365	5.9	115	41,718
Total	**59**	**12,377**	**576,812**	**6.4**	**1133**	**484,557**

Publicly Funded Acute Hospitals Statistics, 2004 Source: Department of Health and Children

Healthcare: Capacity vs Need

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		0.88%				

Potentially 1.4 million individuals may require healthcare attention

Non-Capital Health Expenses €m

Programme	1999	2000	2001	2002	2003	2004	2005
Community Protection Programme	136.0	224.8	314.3	275.3	302.2	334.6	366.2
Community Health Service Programme	883.5	985.0	1,191.6	1,526.1	1,678	1,868.7	2,162.7
Community Welfare Programme	336.5	445.9	581.4	703.8	774.2	860.0	892.1
Psychiatric Programme	394.5	433.7	497.1	563.7	619.5	661.4	729.5
Programme for the Disabled	520.8	651.6	815.9	962.9	1,155.9	1,230.6	1,368.2
General Hospital Programme	2,317.7	2,604.5	3,291.4	3,801.5	4,180.7	4,523.3	4,915.5
General Support Programme	218.1	264.9	318.3	333.5	407.0	444.8	482.4
Gross Total	4,807.3	5,610.3	7,010.1	8,166.7	9,117.4	9,923.4	10,917.8
Total Non-Capital Income	233.4	251.3	270.8	300.2	334.3	362.9	417.8
Net Total	4,573.9	5,359.1	6,739.3	7,866.5	8,783.1	9,960.5	10,500.0

Source: Non-Capital Healthcare Expenses, Department of Health and Children

Healthcare Costs

Source: General Medical Services Report

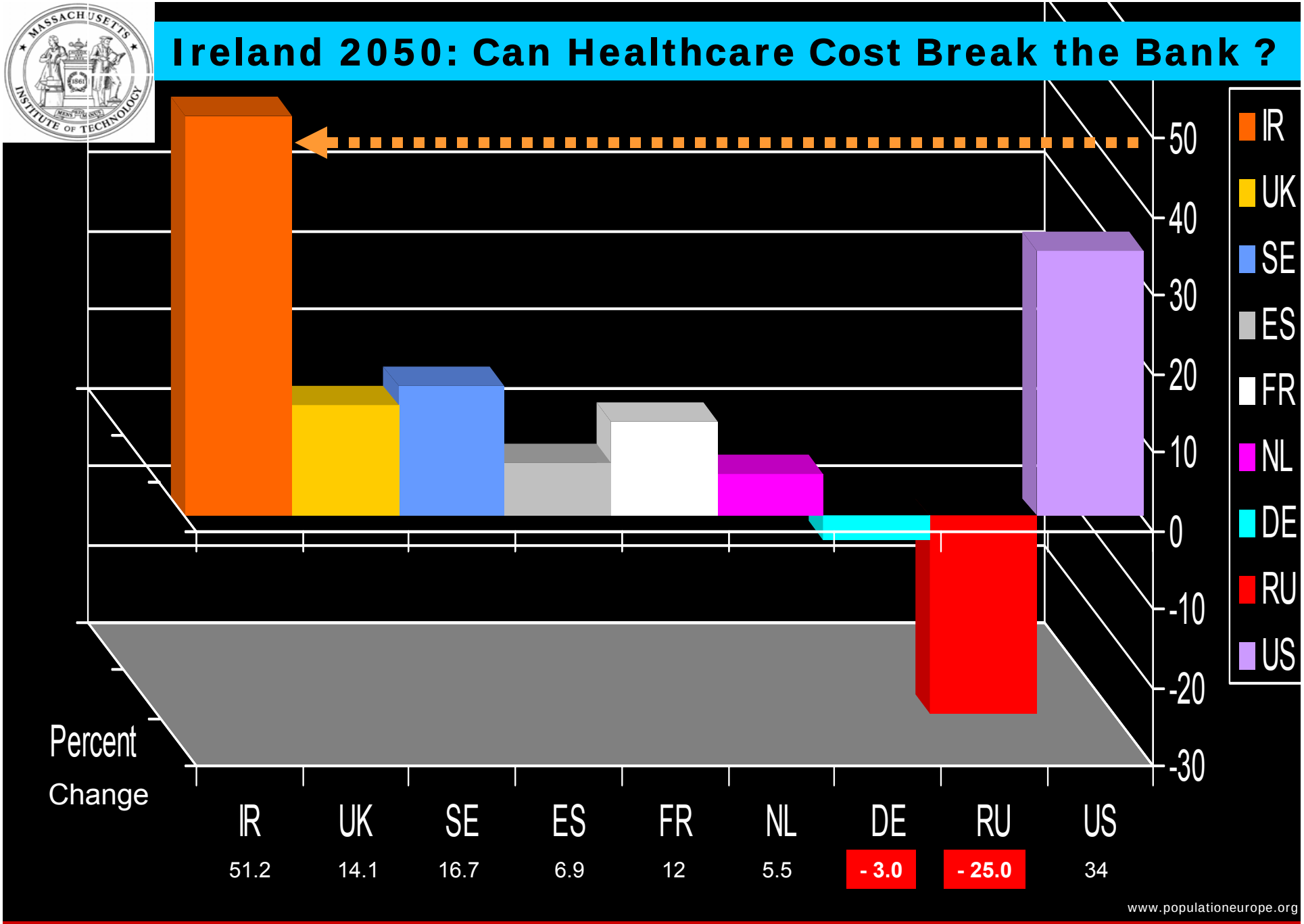
Category	1999	2000	2001	2002	2003	2004	2005
Doctors	154.8	169.9	211.8	282.1	295.7	317.5	414.0
Pharmacists	417.2	527.6	670.9	813.2	937.7	1,085.9	1,189.4
Dentists	18.3	38.1	41.7	45.7	49.9	52.5	54.5
General Practice Development	9.3	10.2	11.6	17.6	13.1	15.8	11.9
High Tech Drugs Scheme	42.3	51.9	65.1	84.6	109.1	148.2	177.5
Optometrists	1.8	8.7	9.8	13.9	13.8	17.4	17.0
Administration	9.3	11.8	12.7	13.7	12.5	15.5	17.0
Payments by General Medical Services Board €m							
Gross Total	653.0	818.2	1,023.6	1,270.9	1,431.8	1,652.5	1,881.3

2008 Hospital Charges

Hospital Category	Private	Semi-Private	Day-Care
HSE Regional Hospitals Voluntary & Joint Board Teaching Hospitals	€758	€594	€546
HSE County Hospitals Voluntary Non-Teaching Hospitals	€506	€407	€362
HSE District Hospitals	€217	€185	€161

Source: www.citizensinformation.ie

Ireland 2050: Can Healthcare Cost Break the Bank ?



www.populationeurope.org

Diabetes in Ireland

- 200,000 type II diabetes mellitus patients
- 100,000 people with high blood glucose levels
- In next 5 years 50% of above will be diabetic
- Obesity will push the figure (100,000) to double in the next decade (potential risk for 200,000).

Source: www.diabetes.co.uk/global-diabetes/diabetes-in-ireland.html
Source: www.diabetesireland.ie

Diabetes

- 200,000 type II diabetes mellitus patients

Basic Risk Profile needs Blood Glucose data

Diabetes

- 200,000 type II diabetes mellitus patients

Basic Risk Profile needs Blood Glucose data

200,000 patients will not have same risk profile

Only few will have high risk, for example:

[1] genetic predisposition
[2] nephropathy
[3] glaucoma

Diabetes

- 200,000 type II diabetes mellitus patients

Basic Risk Profile needs Blood Glucose data

200,000 monthly out-patient visits ?

Diabetes

- 200,000 type II diabetes mellitus patients

Basic Risk Profile needs Blood Glucose data

200,000 monthly out-patient visits

If transaction cost is €20 per patient per month

Blood glucose profile €48 million pa

Diabetes Risk

- 200,000 type II diabetes mellitus patients

Blood Glucose data from 200,000 patients

Blood Glucose data from 100,000 at risk pool

Diabetes Risk

- 200,000 type II diabetes mellitus patients

Blood Glucose data from 200,000 patients

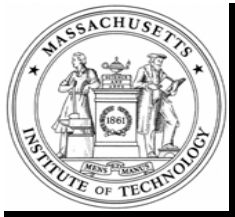
Blood Glucose data from 100,000 at risk pool

Without out-patient visits

Innovation: Need Based

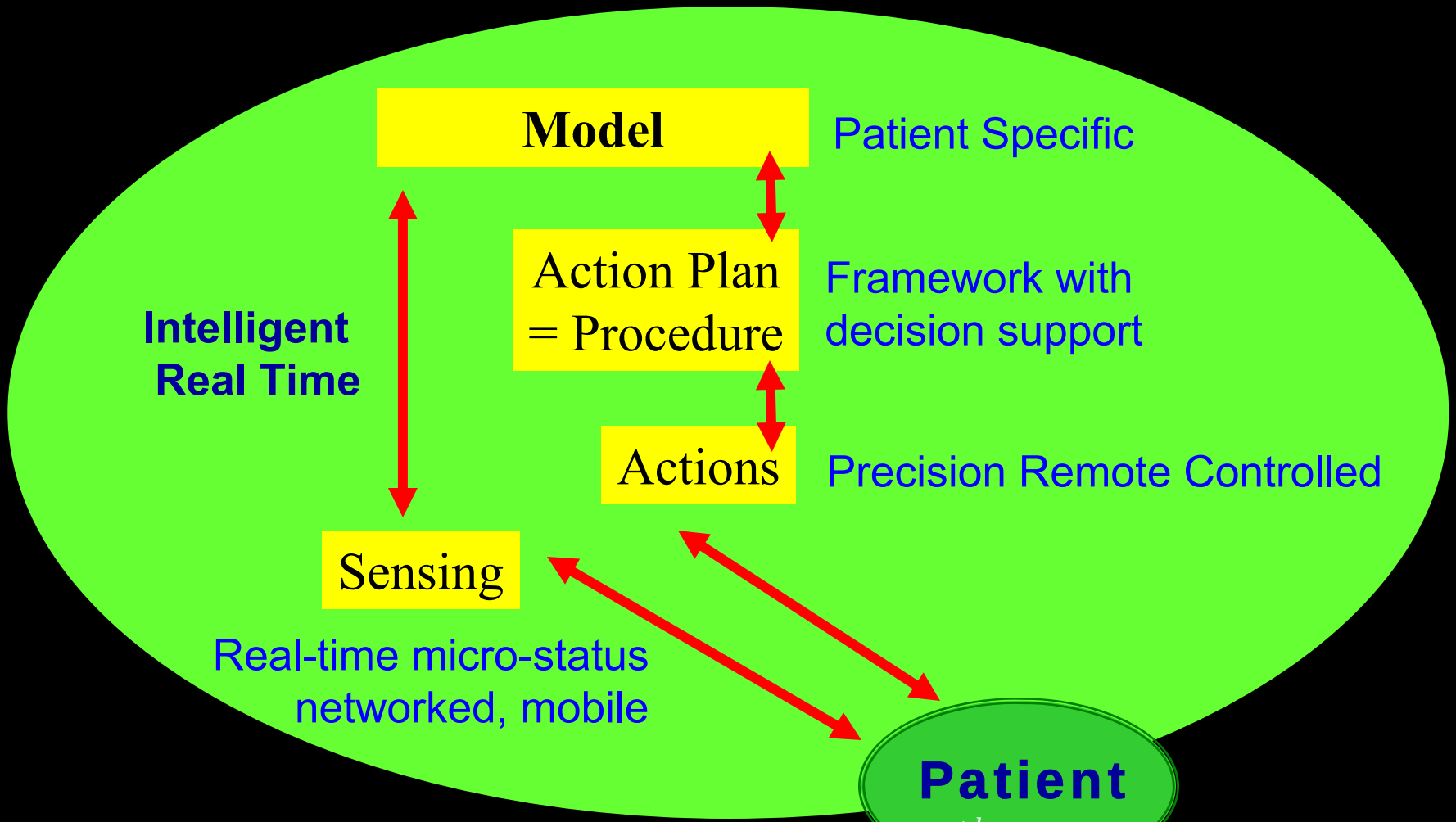
Problem: Healthcare Cost

NanoLetters (2004) 4 1785-1788



Healthcare for Independent Living

Sense, *then*, Respond



Innovation: Need Based

Problem: Healthcare Cost

Solution: Sense then Respond

NanoLetters (2004) 4 1785-1788

Healthcare Systems ROI

Renato Dulbecco

Problem: 300,000 outpatient visits

30,000 genes in

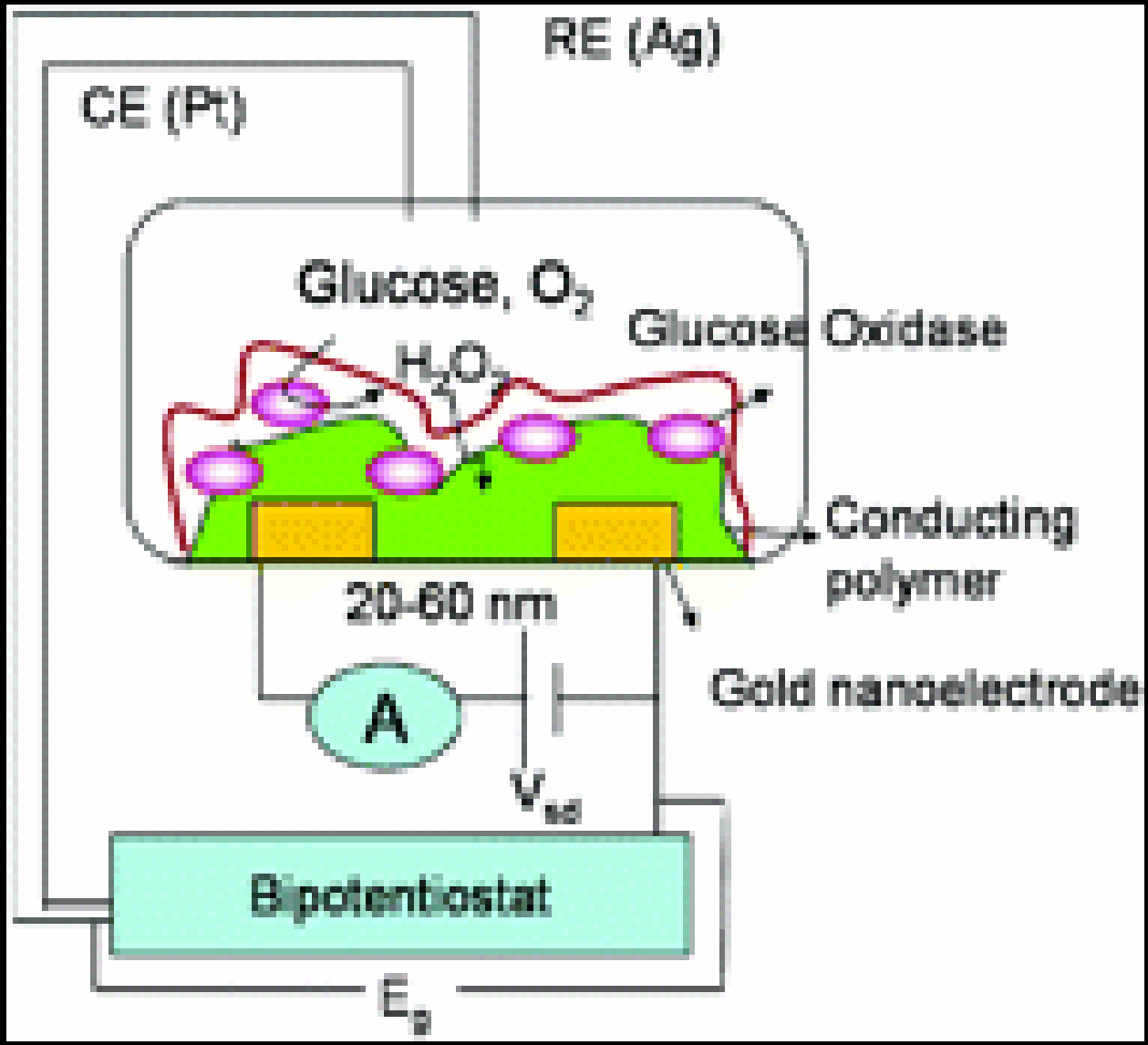
etiology of cancer

3,000 patients in need of attention

1 gene elicits cancer

Nobel Prize in Medicine

Tool: Glucose Nano-sensor



NanoLetters (2004) 4 1785-1788

Innovation: Need Based

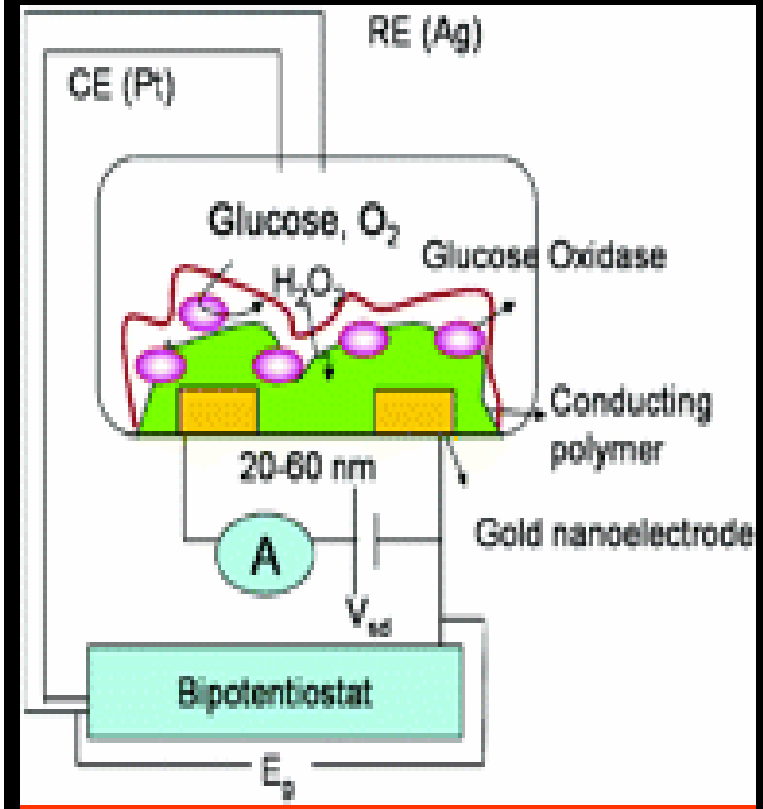
Tool: Glucose Nano-sensor

Problem: Healthcare Cost

Solution: Sense then Respond

NanoLetters (2004) 4 1785-1788

May I implant a glucose nano-sensor in you? You are fat, you could be diabetic!



Blood Glucose Nano-sensors

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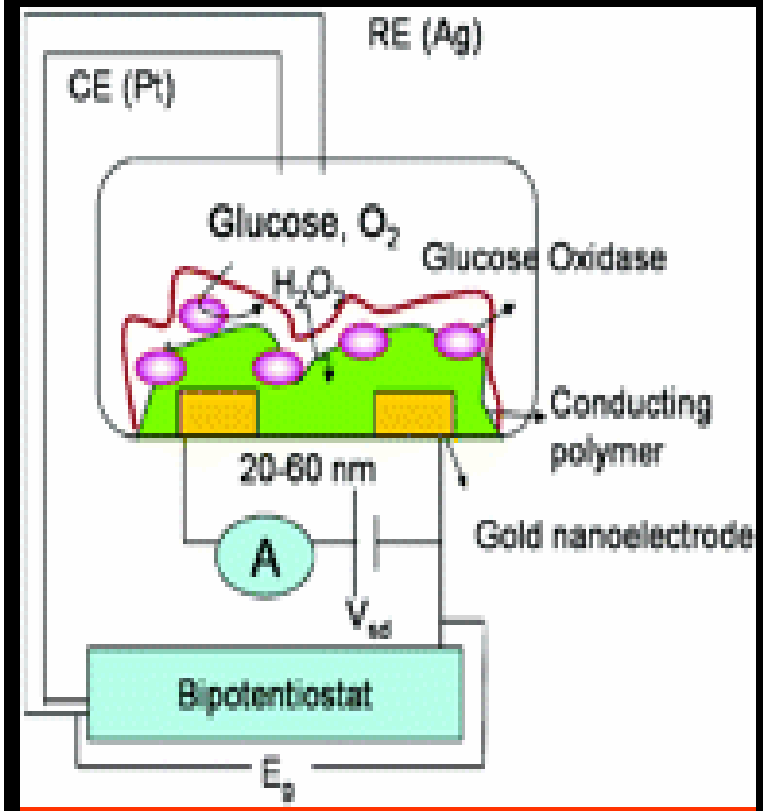
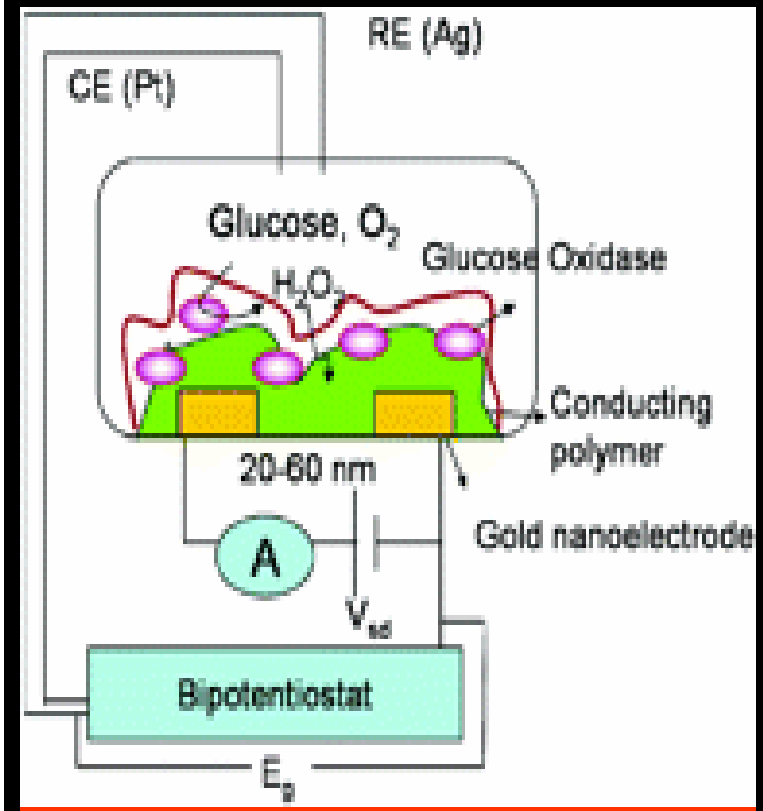


Blood Glucose Nano-sensors

Aren't you glad to have a chip on your shoulder?



Blood Glucose Nano-sensors

Innovation through Convergence

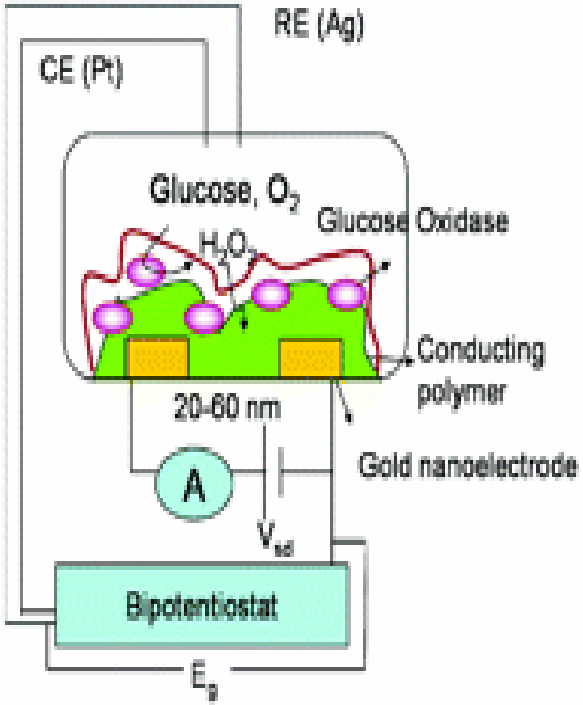
SENSOR + DATA TRANSMITTER

Innovation through Convergence

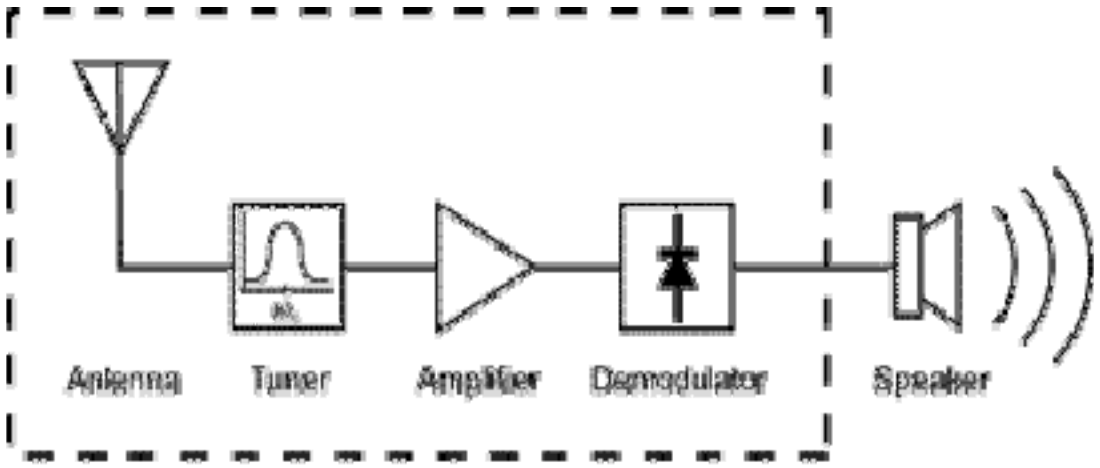
SENSOR + DATA TRANSMITTER

NanoLetters (2004) 4 1785-1788

NanoLetters (2007) 7 3508-3511



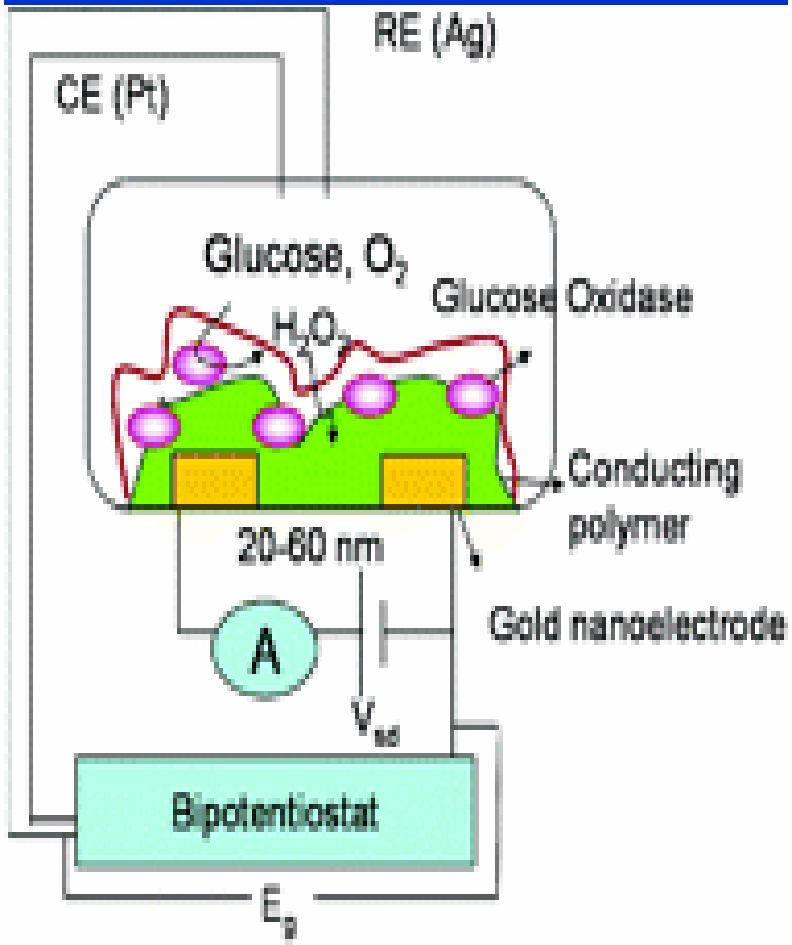
Blood Glucose Nano-sensor



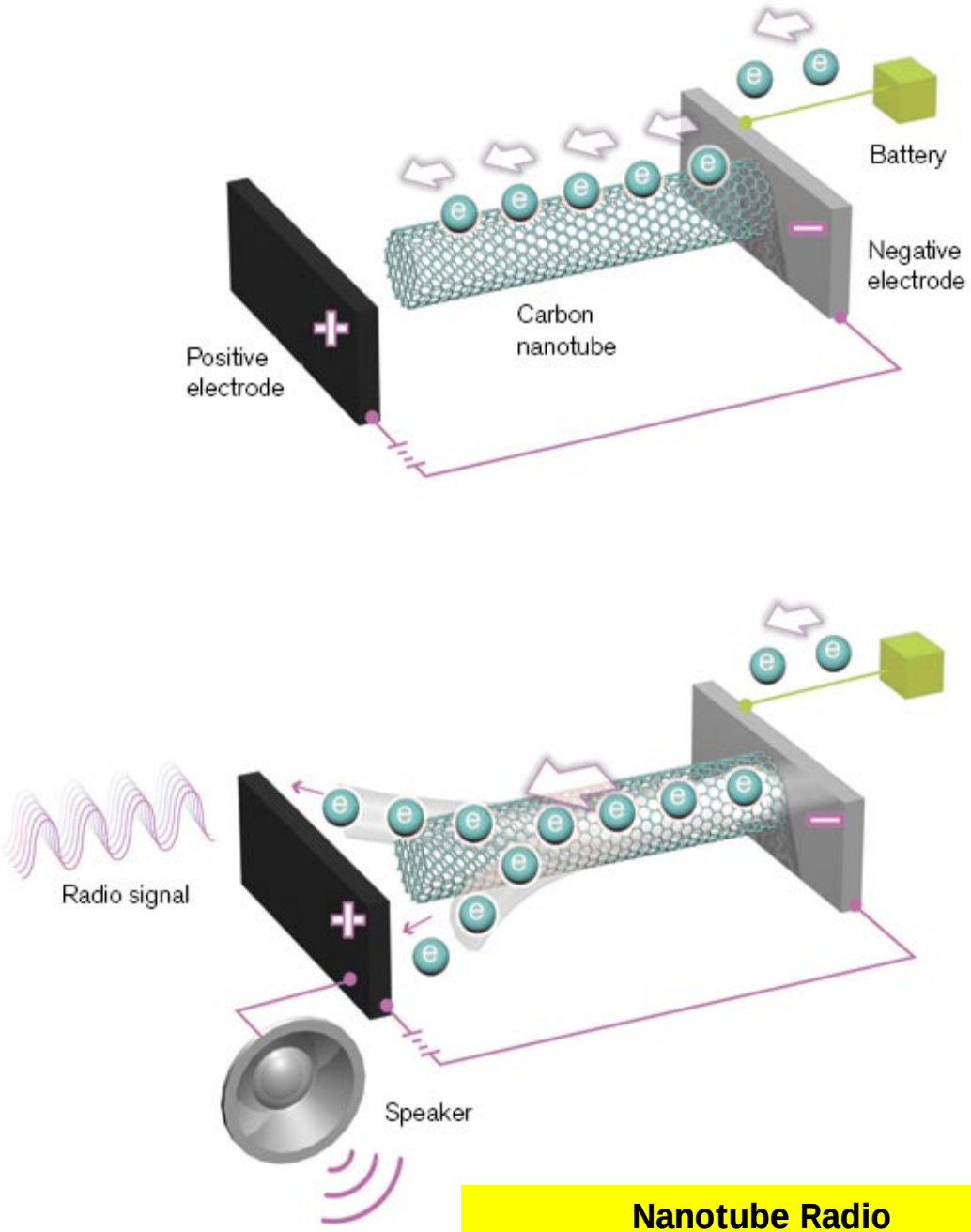
All-in-one nanotube radio

Innovation

SENSOR DATA



Blood Glucose Nano-sensor



Nanotube Radio

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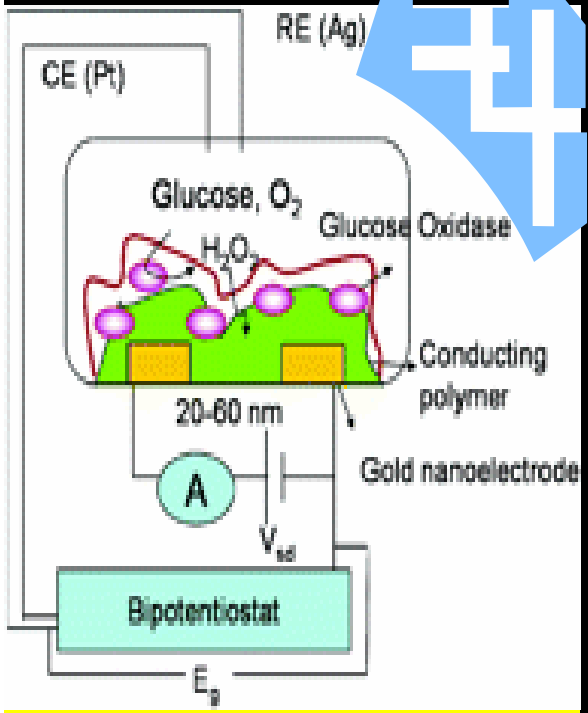
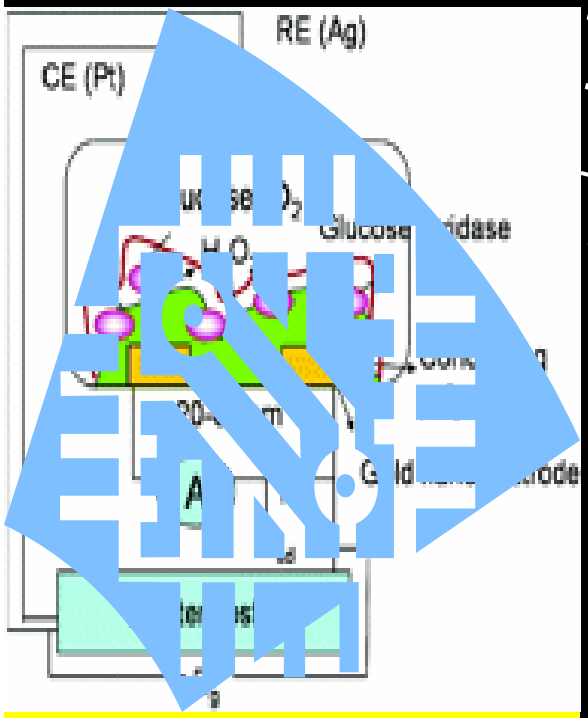
NanoLetters (2007) 7 3508 – 3511
MIT Tech Review March/April 2008

Glucose NanoSensor NanoRadio



Glucose Nano-sensor Radio

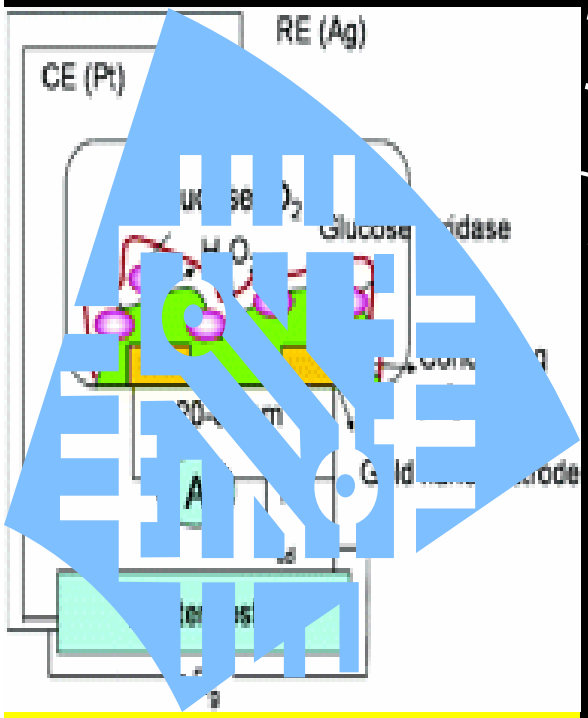
Implanted wireless nano-sensor transmits blood glucose data every minute or every hour using WiFi



802.11b
WiFi
802.11g

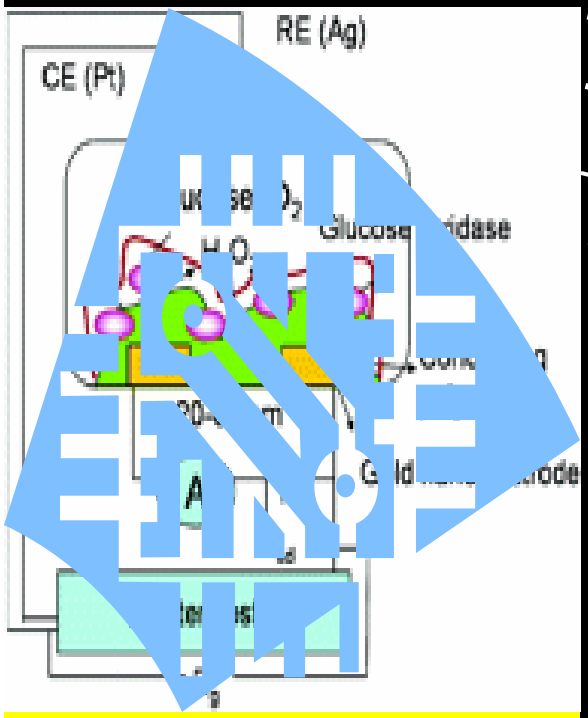
Glucose Nano-sensor Radio

Your blood glucose data can be transmitted from home or office or bus station, wherever WiFi can connect to a node on the internet

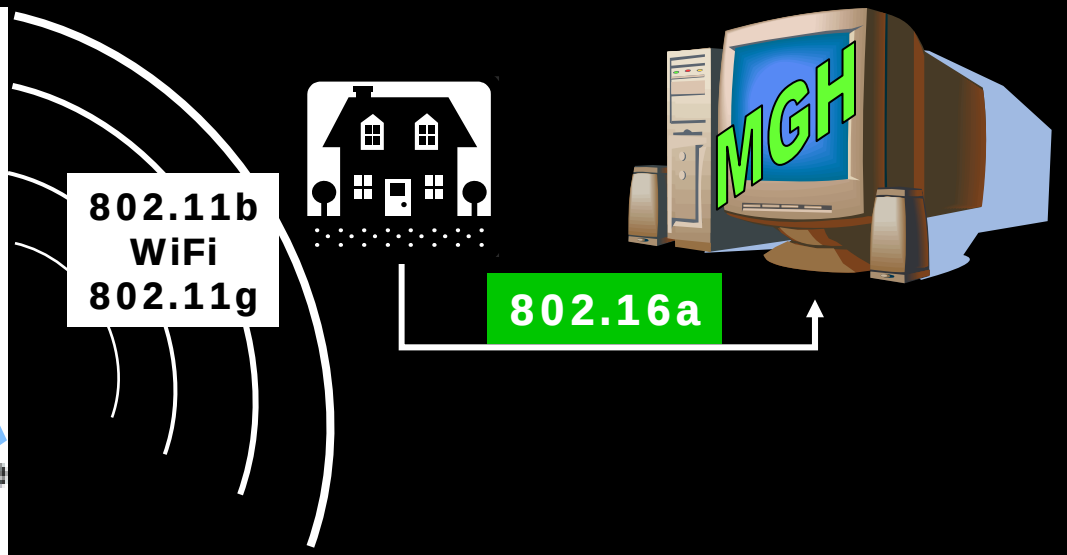


Glucose Nano-sensor Radio

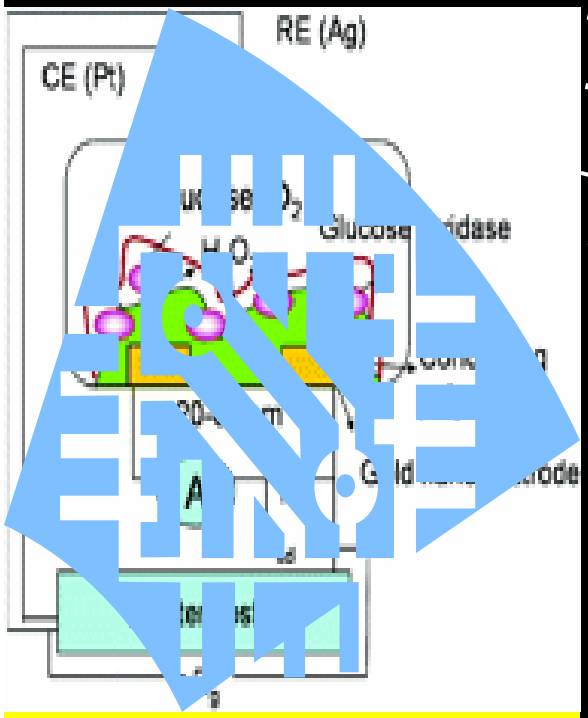
Blood glucose data travels from you to your hospital or clinic via broadband or WiMax connection



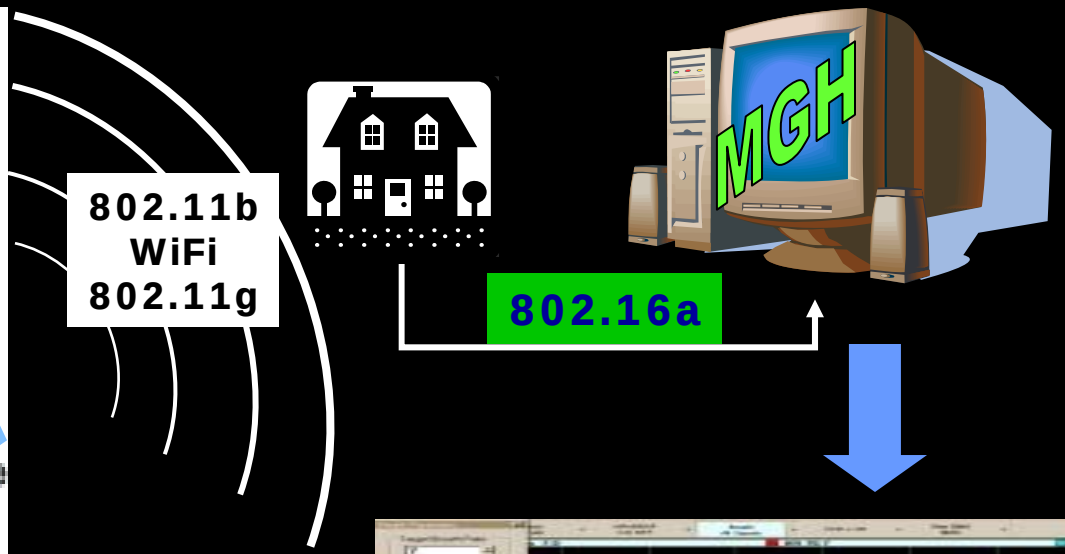
Glucose Nano-sensor Radio

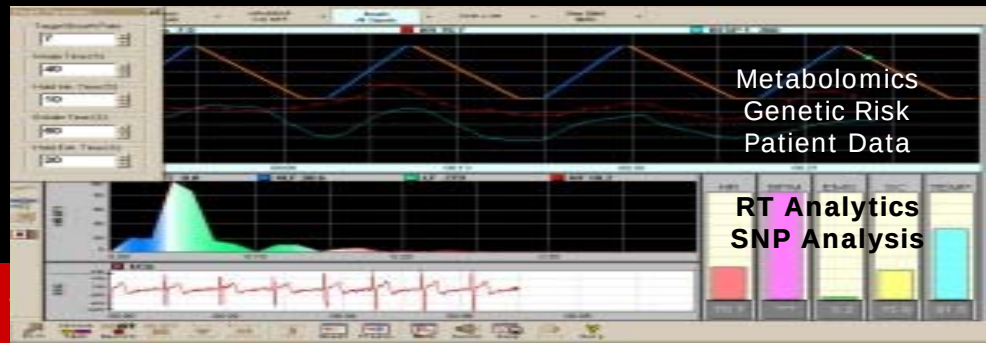


Your blood glucose data generates your risk profile that is analysed by hospital to determine your status



Glucose Nano-sensor Radio





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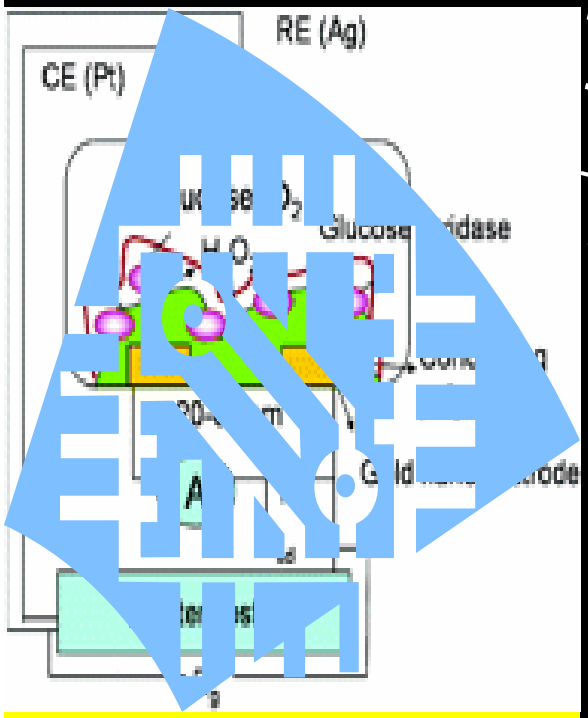
If you need medical attention or insulin or other treatment then hospital sends you a message



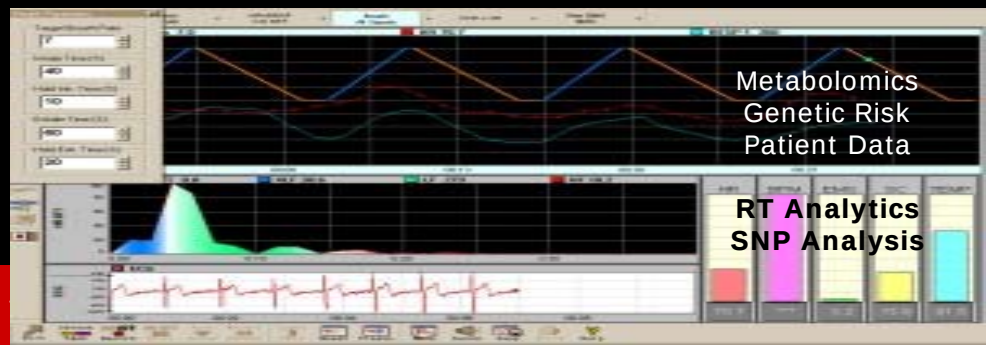
Glucose Nano-sensor Radio

802.11b
WiFi
802.11g

802.16a

MGH

VISIT CLINIC



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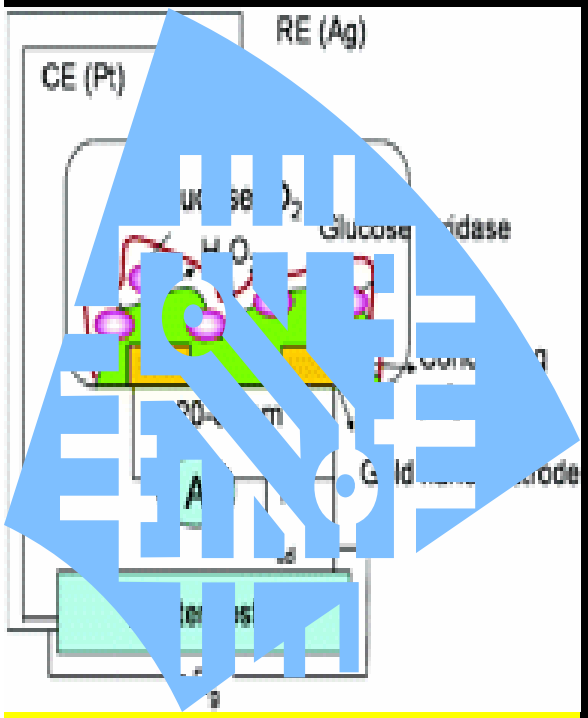
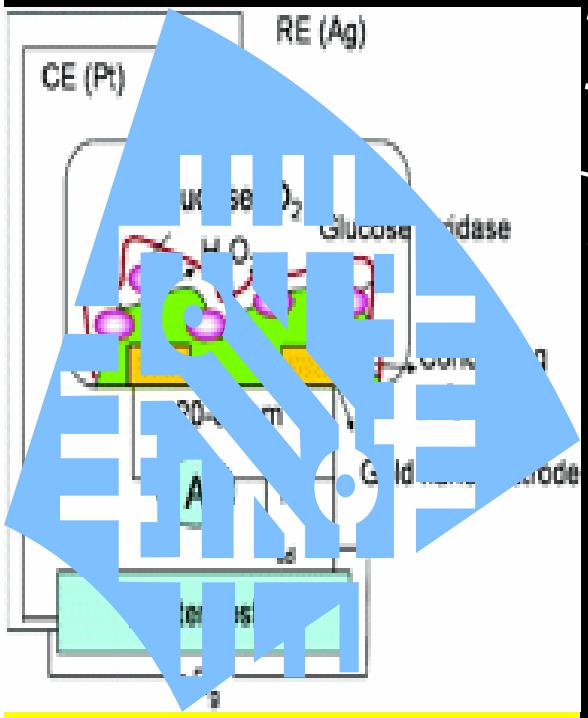


Glucose Nano-sensor Radio

Healthcare Cost Reduction

Instead of out patient visits by all

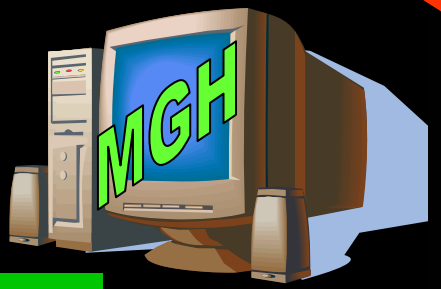
Identify the one in need of attention

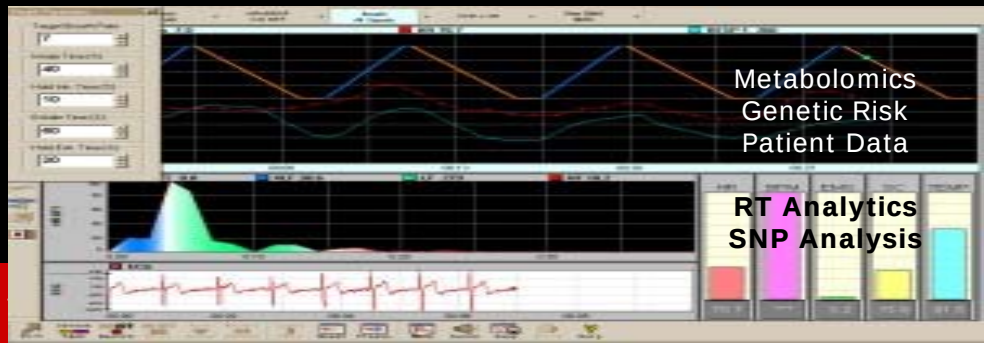


Glucose Nano-sensor Radio

802.11b
WiFi
802.11g

802.16a





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Healthcare Cost Reduction: Convergence

Bio-sensors, Nanotechnology, ICT and Analytics

- ✓ **New Products**
- ✓ **New Services**
- ✓ **New Markets**

Healthcare Cost Reduction: Convergence

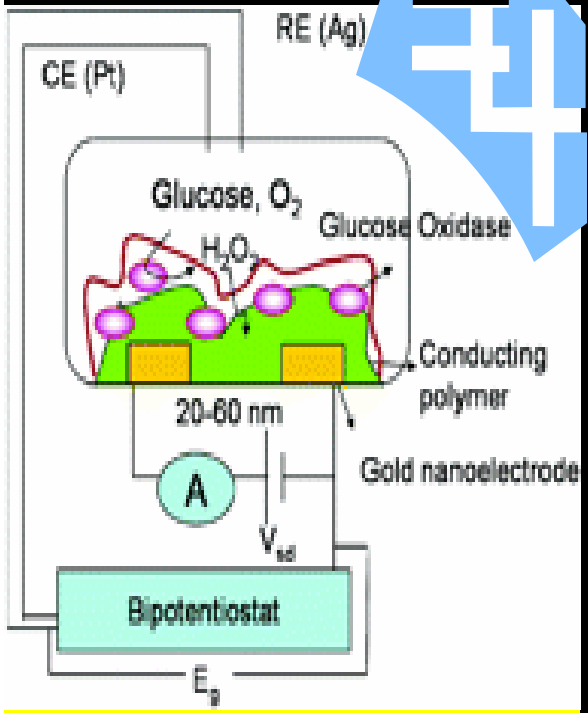
Bio-sensors, Nanotechnology, ICT and Analytics

✓ **New Products**

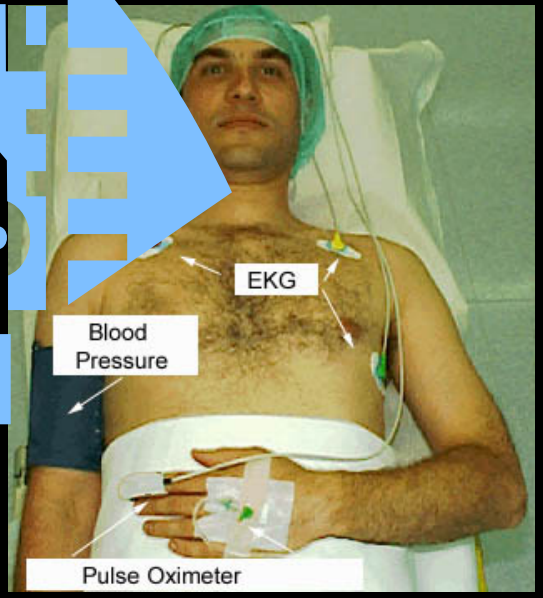
Healthcare Cost Reduction: Convergence

Bio-sensors, Nanotechnology, ICT and Analytics

✓ New Products



Glucose Nano-sensor Radio



Healthcare Cost Reduction: Convergence

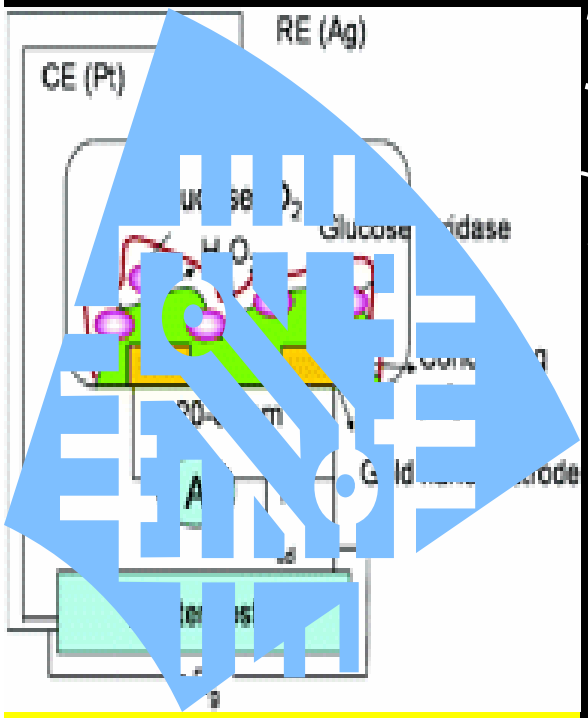
Bio-sensors, Nanotechnology, ICT and Analytics

✓**New Services**

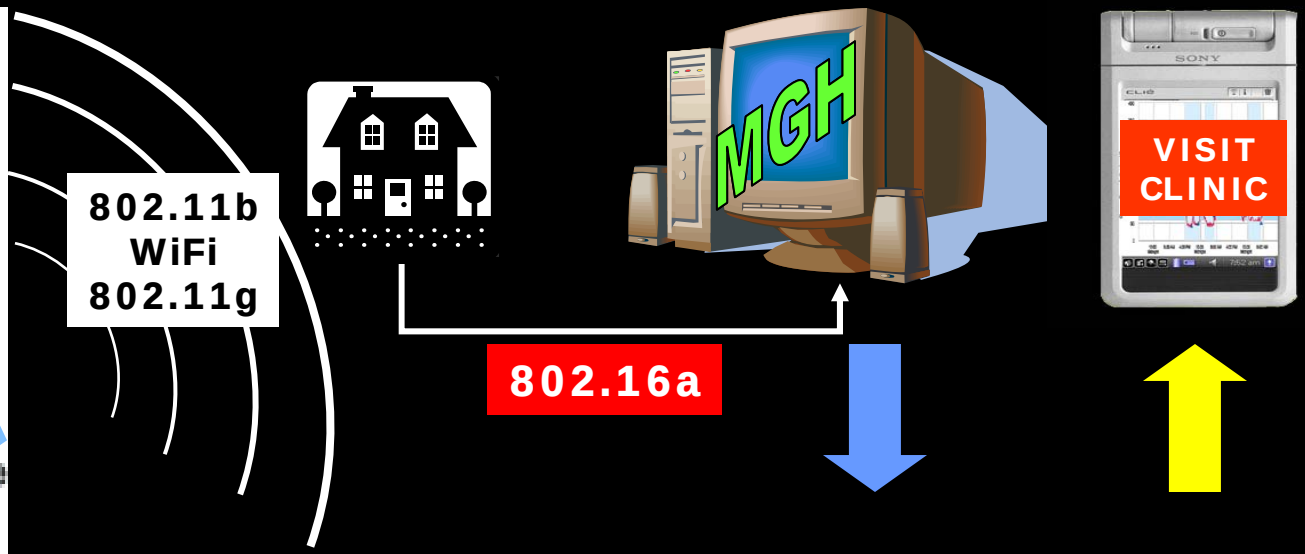
Healthcare Cost Reduction: Convergence

Bio-sensors, Nanotechnology, ICT and Analytics

✓New Services



Glucose Nano-sensor Radio



Healthcare Cost Reduction: Convergence

Bio-sensors, Nanotechnology, ICT and Analytics

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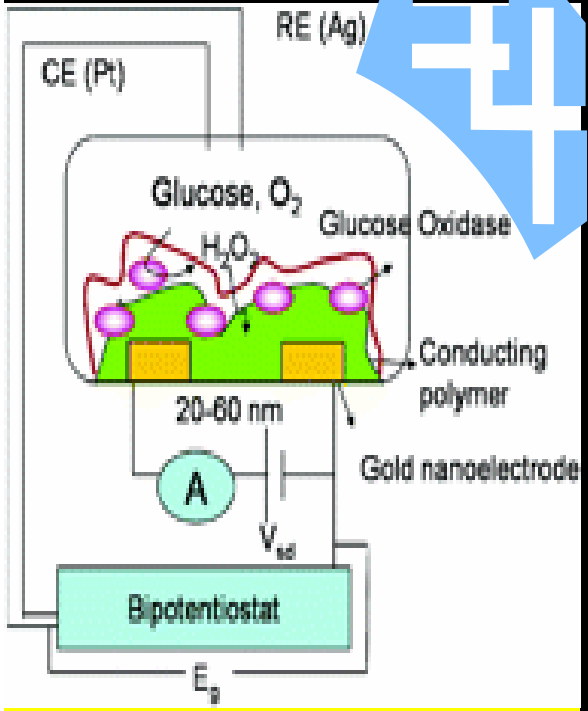

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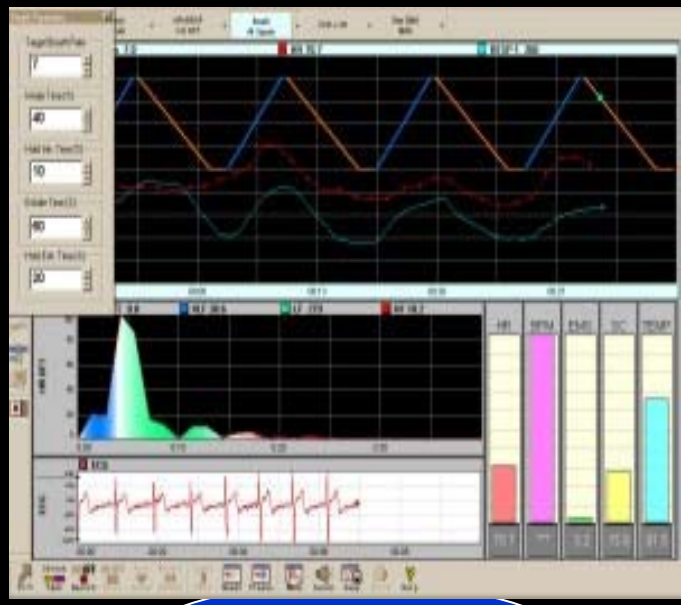
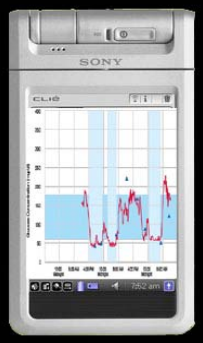




Intelligent ⟷ Analytics

Medical Google

Healthcare Cost Reduction: Convergence

Bio-sensors, Nanotechnology, ICT and Analytics

✓**New Markets**

Demographics Determine Market Growth Strategy

✓New Markets

Demographics Determine Market Growth Strategy

✓New Markets

Europe	Population (millions)	Under 19 (millions)	Over 65 (millions)	Over 65 % population
1950	350	70	14	4.0
2000	450	60	40	8.9
2050	400	40	90	22.5

Demographics Determine Market Growth Strategy

✓New Markets

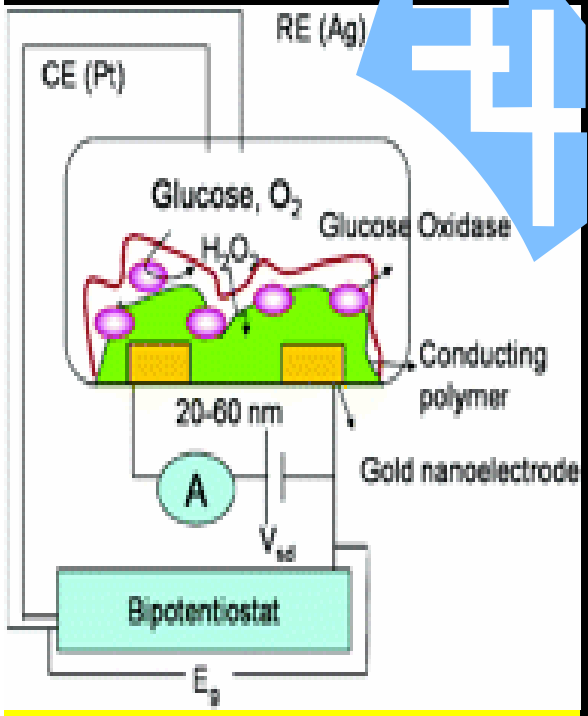
Median Age 2015
China ~ 45
India ~ 25

Population 2025
1.5 billion each

Emerging Markets for
- Innovative Products
- Lifestyle Services

Demographics Determine Market Growth Strategy

✓New Markets



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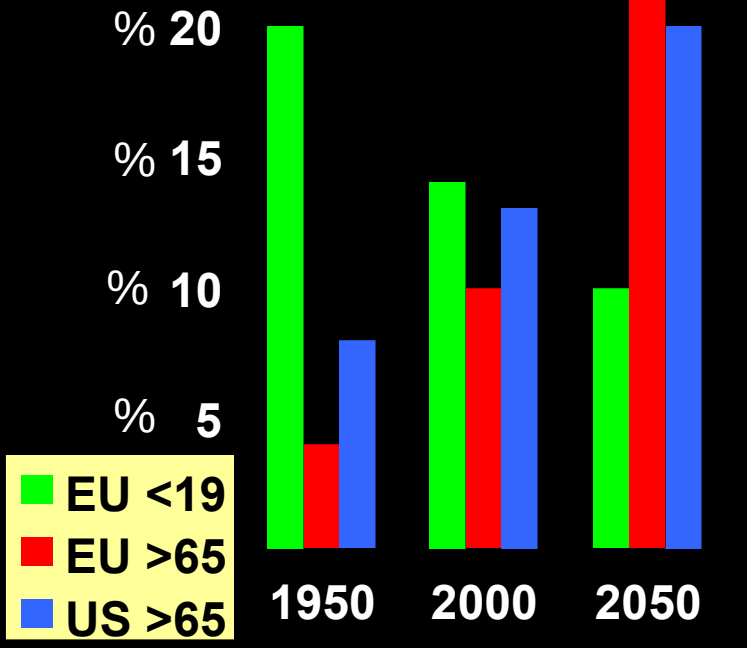

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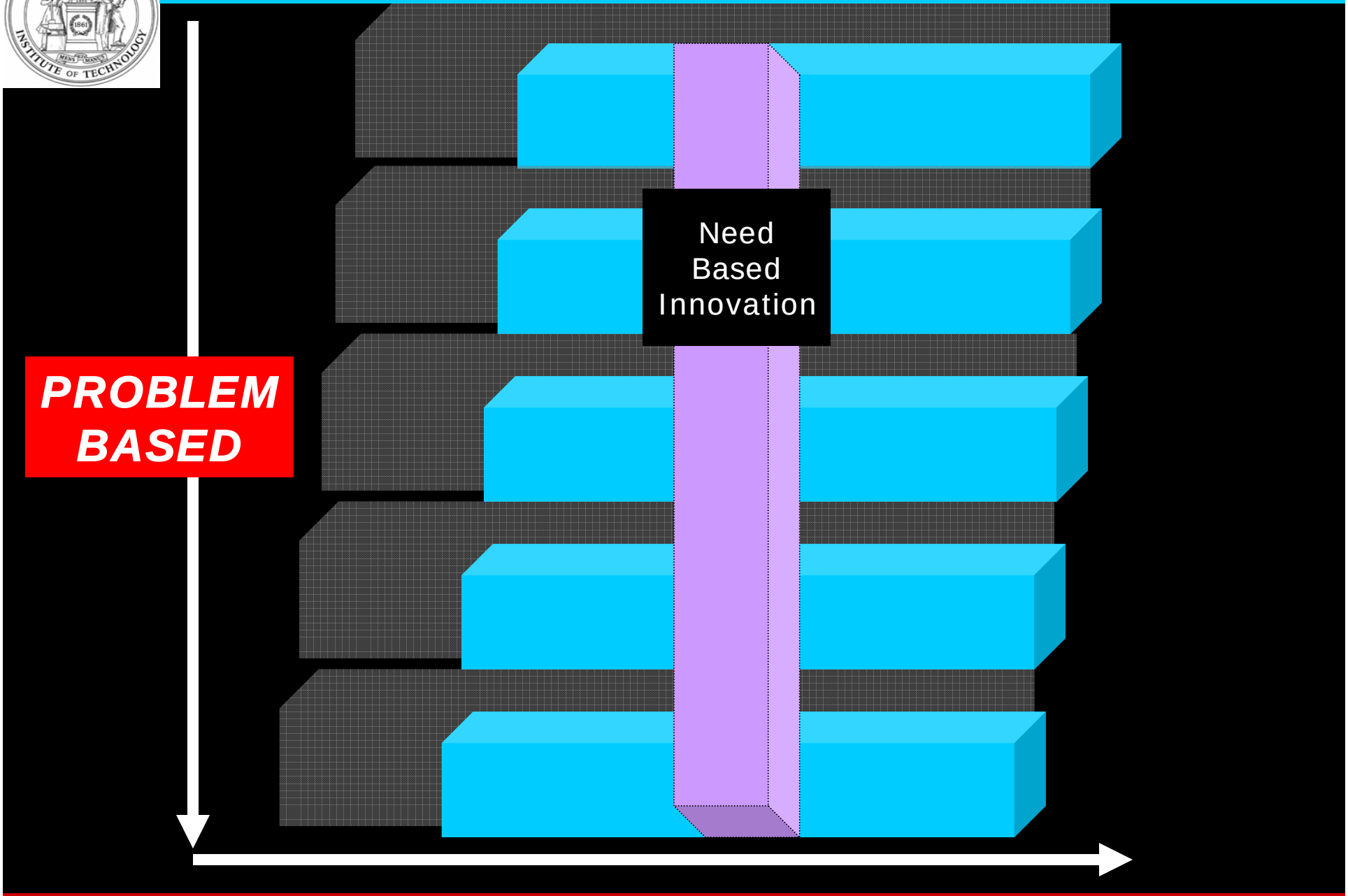
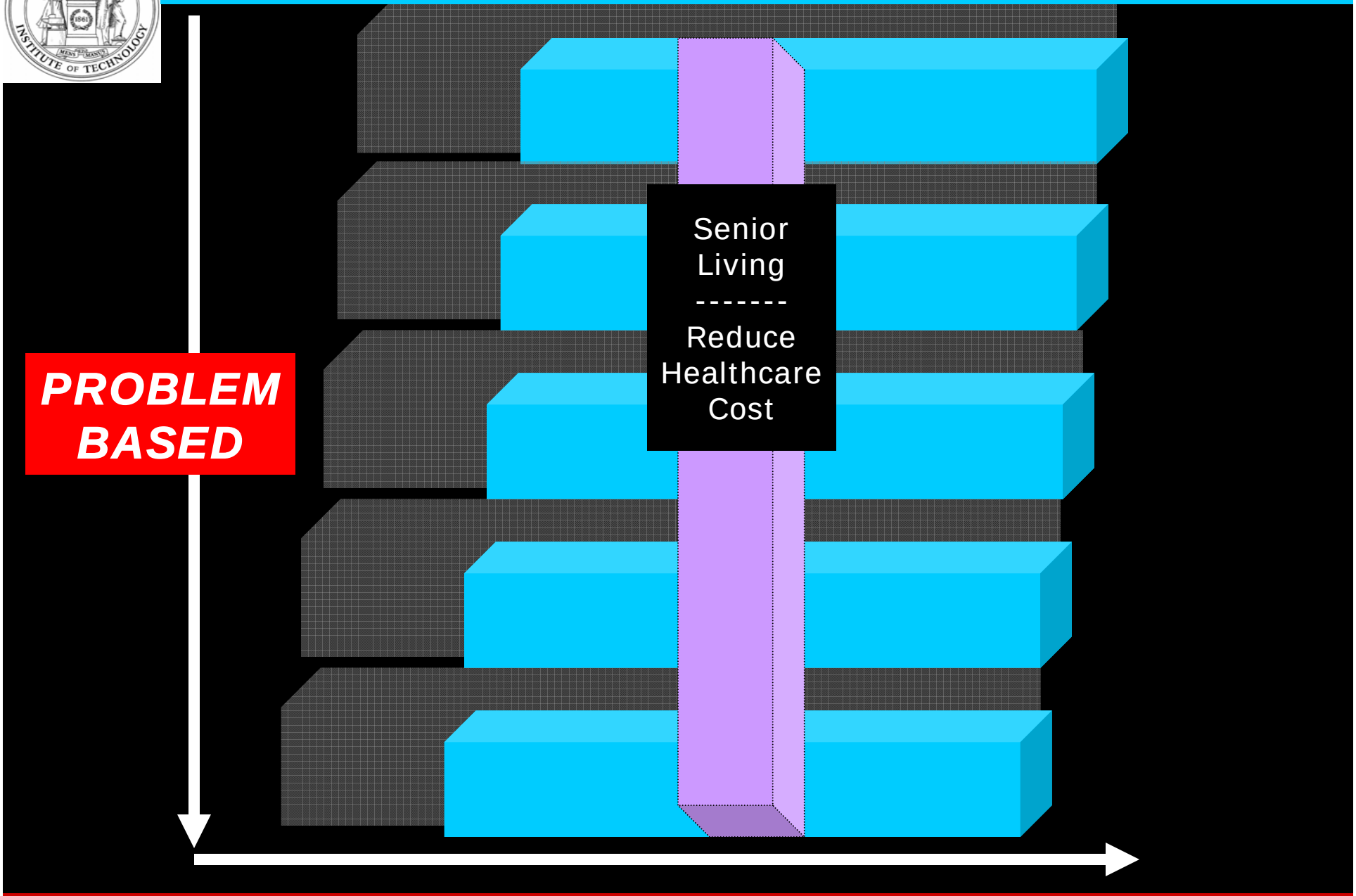
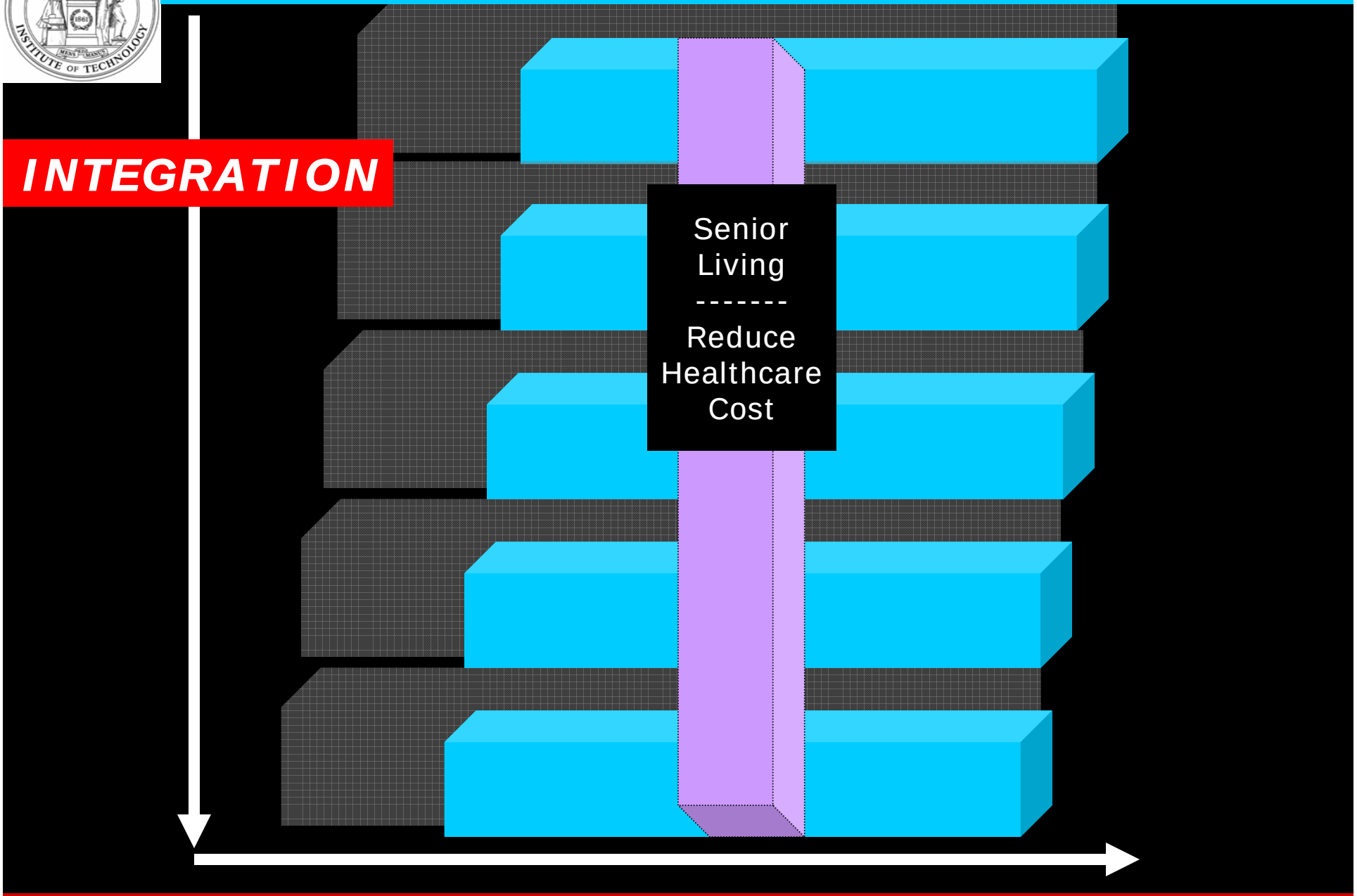
Knowlegde Society: Innovative Knowledge Economy



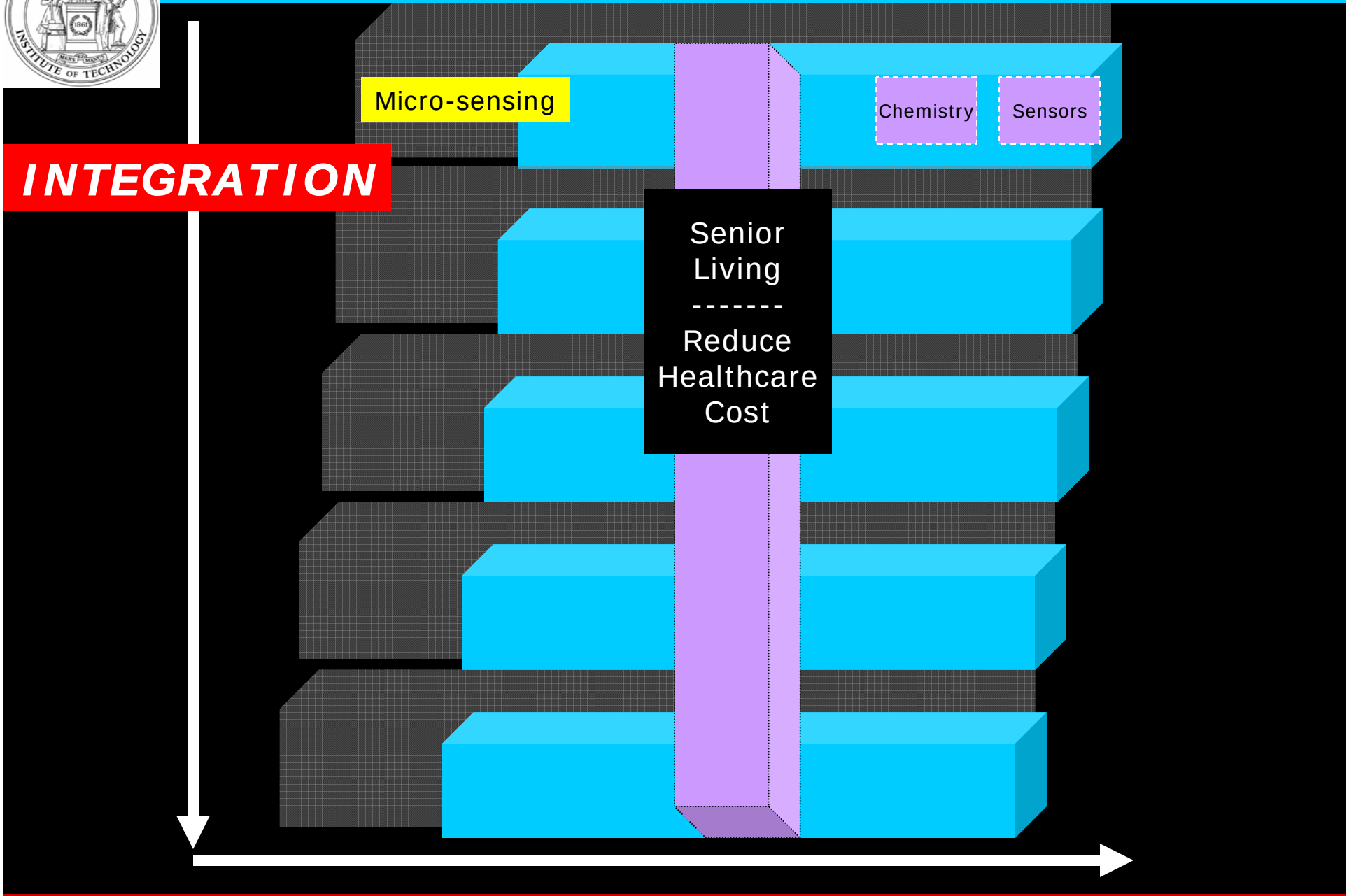
Theme: Independent Senior Communities



Theme: Innovation to Improve Quality of Life



Innovation in Knowledge Economy: Systems Society



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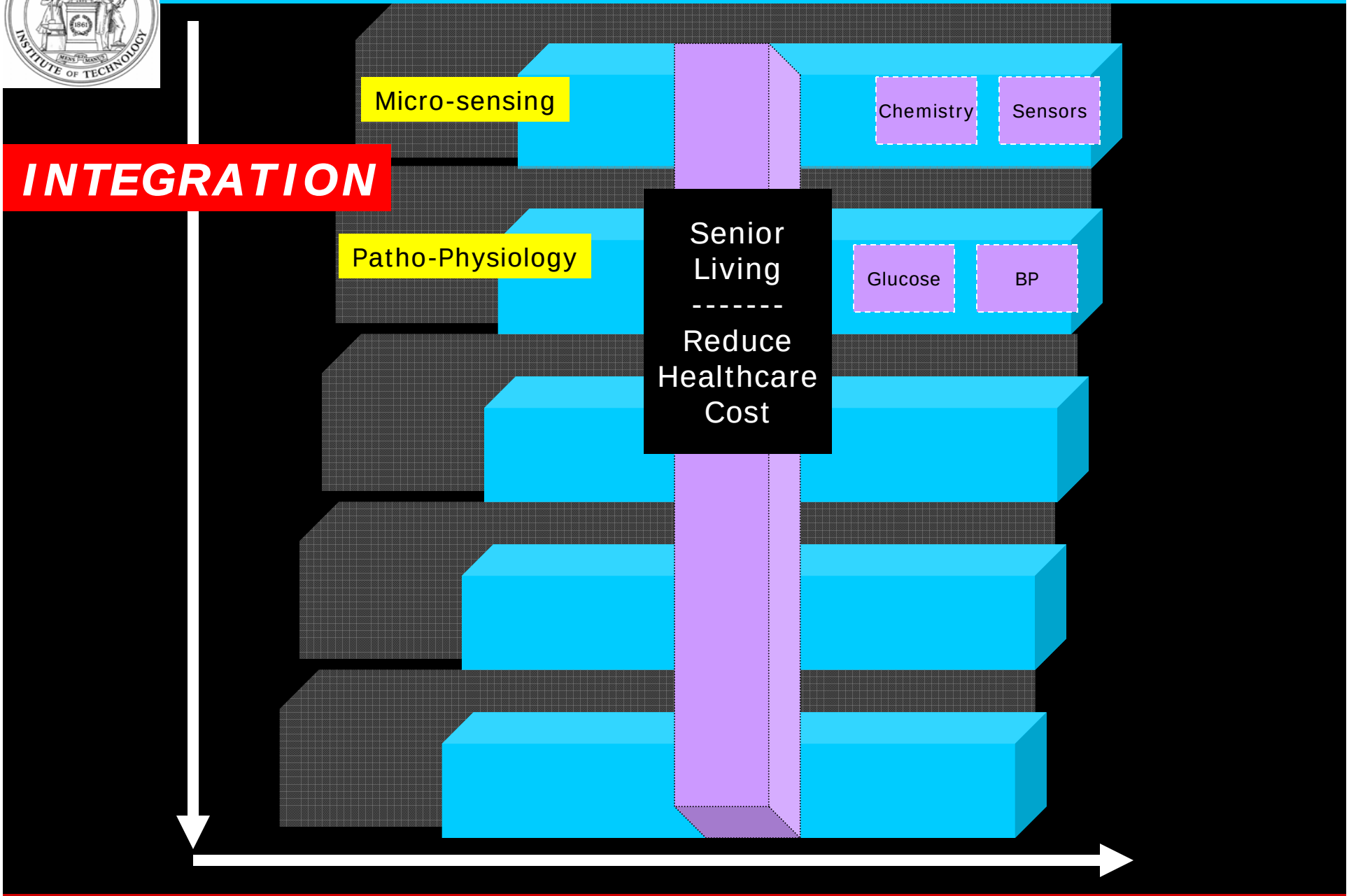

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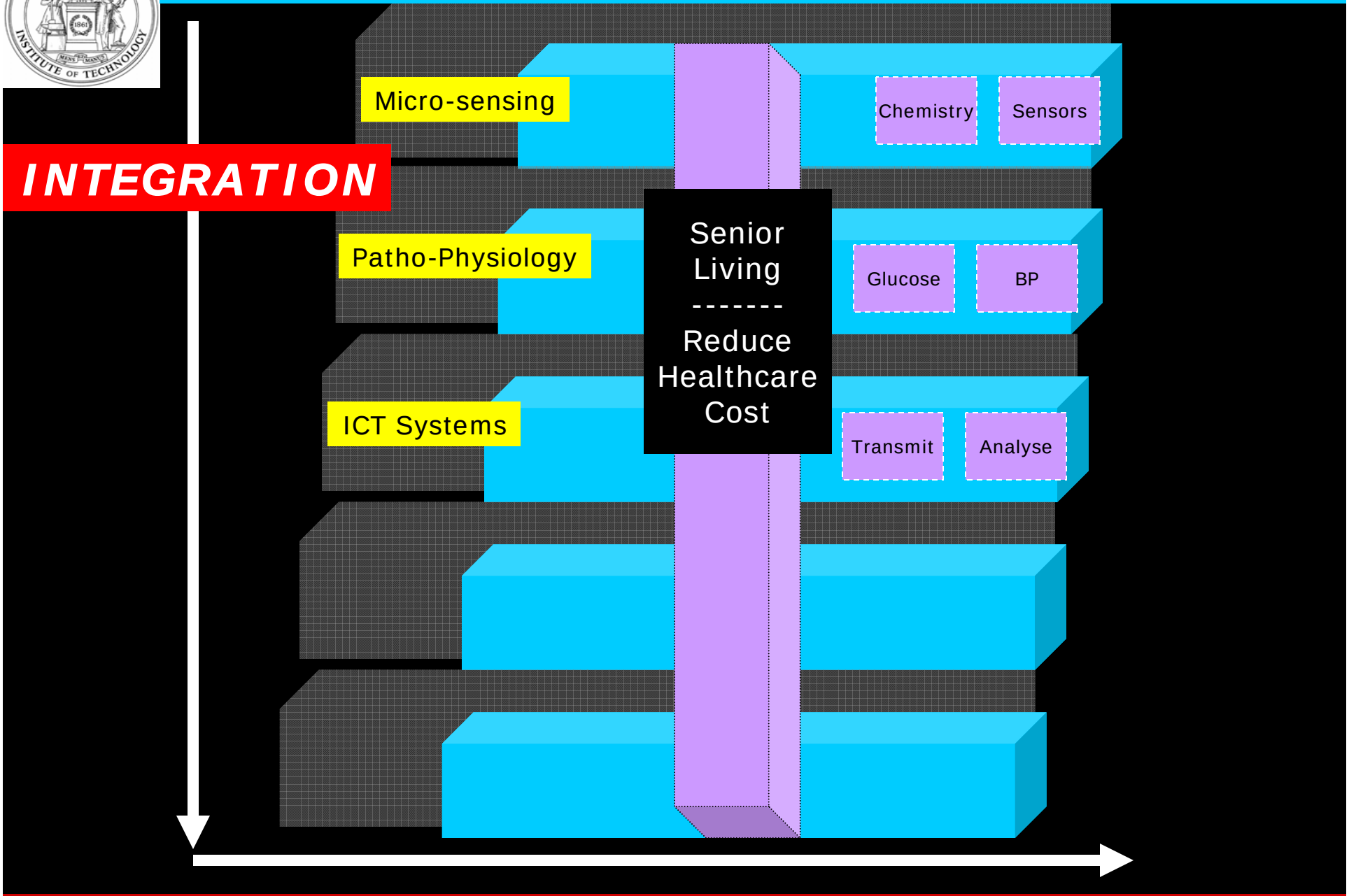

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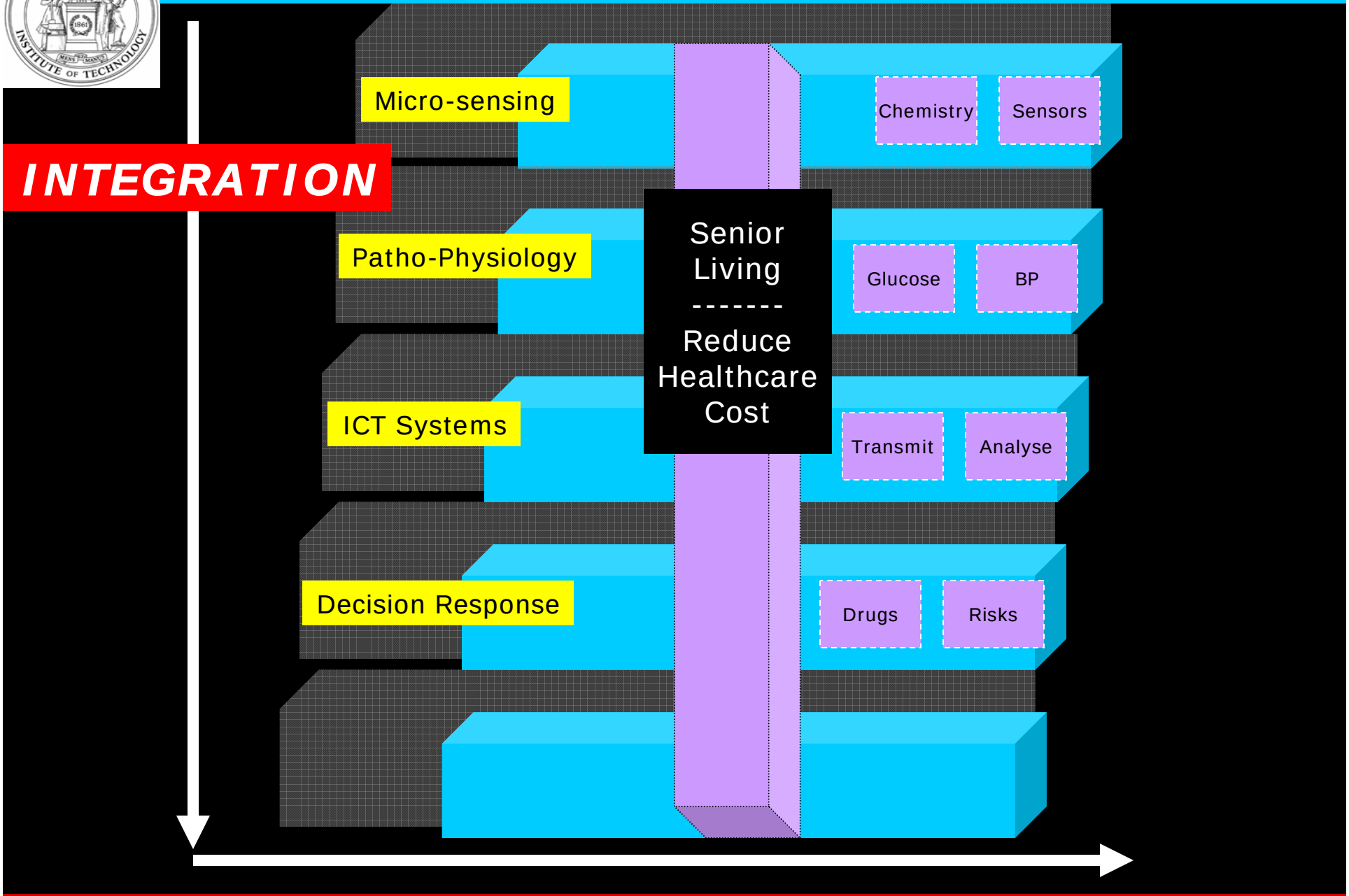

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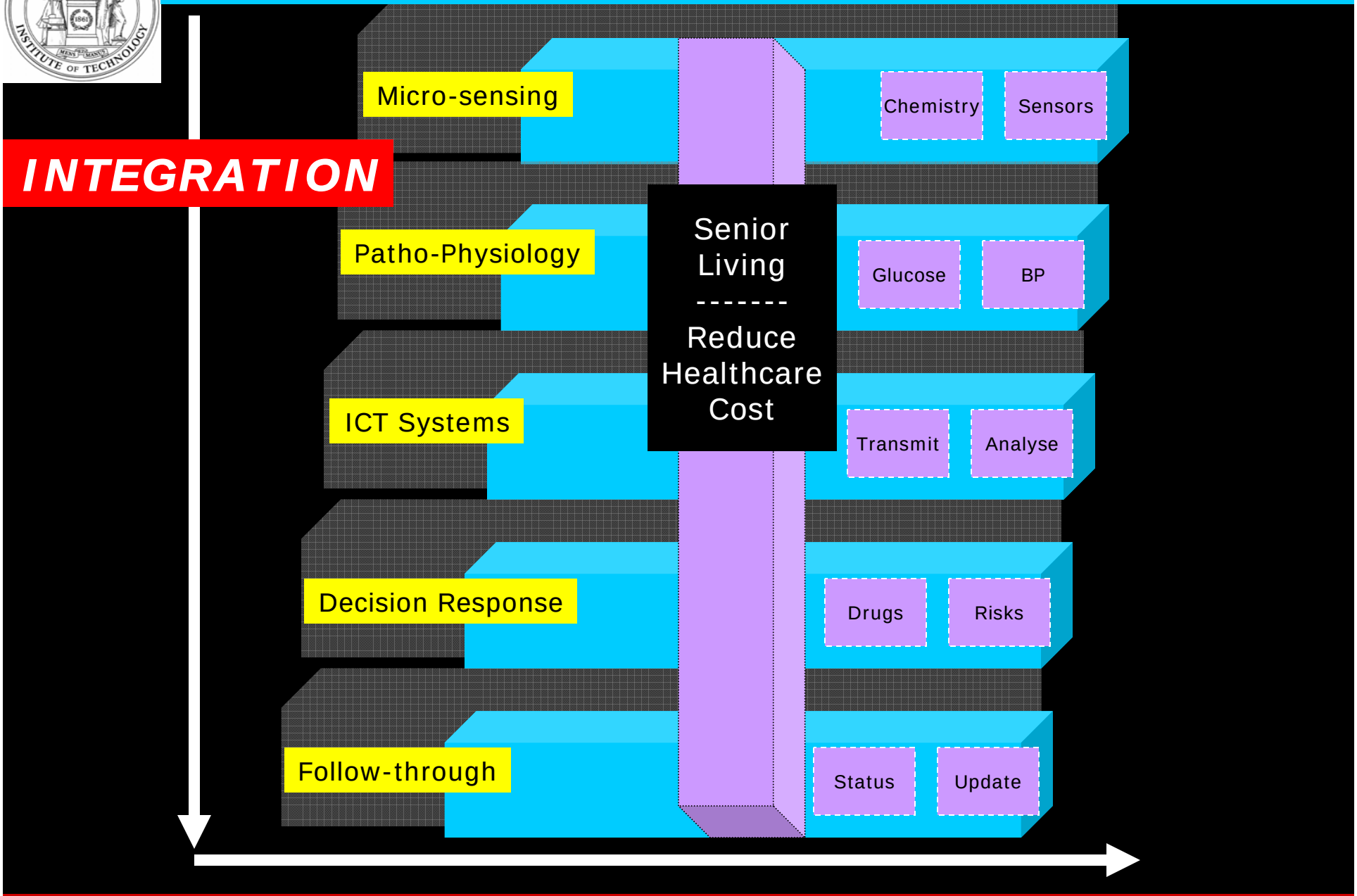
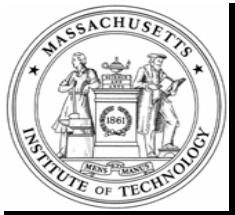
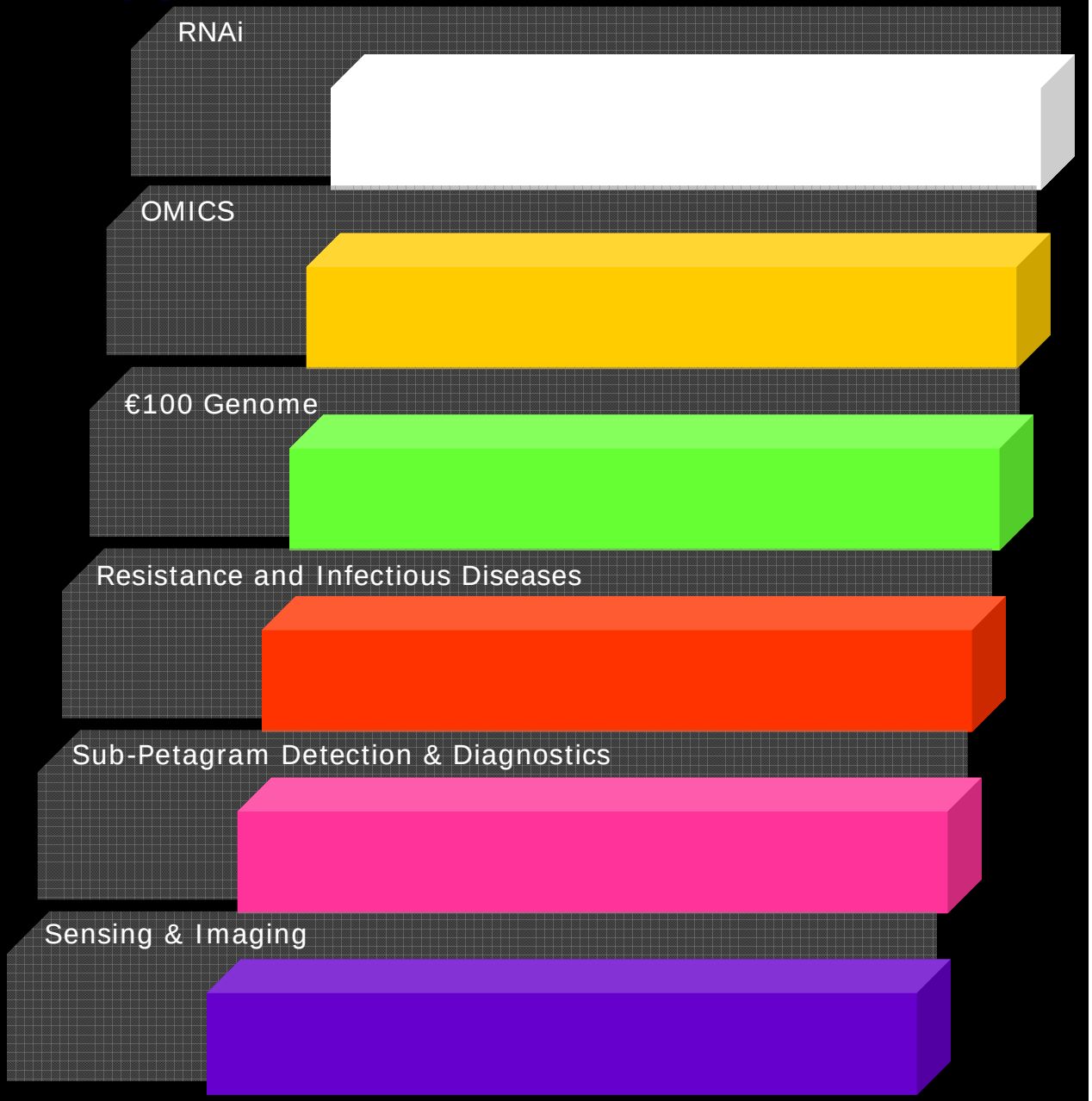




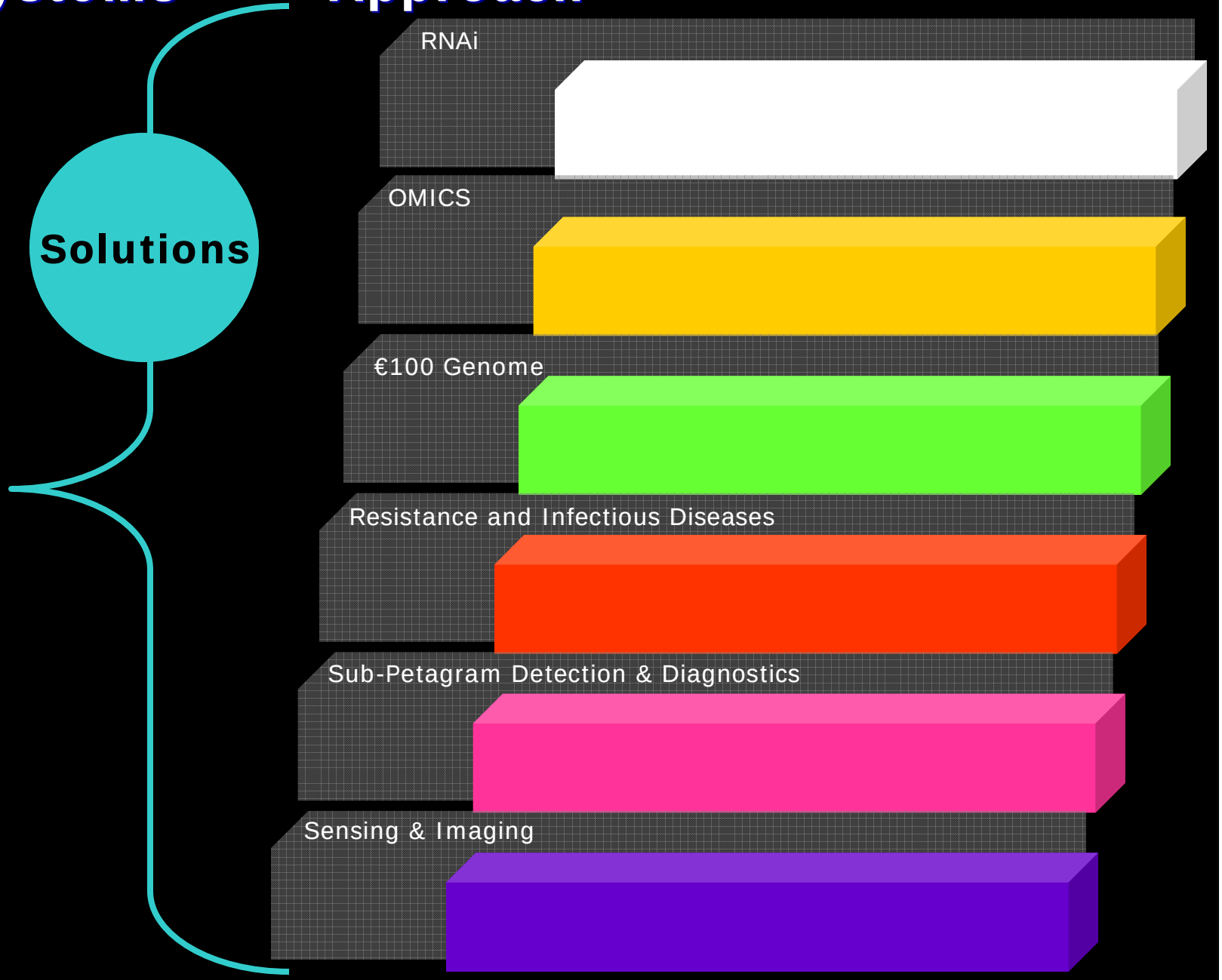
Systems Approach to Economic Growth

- Biomedical
- Healthcare
- Pharmaceutical

Systems Approach



Systems Approach



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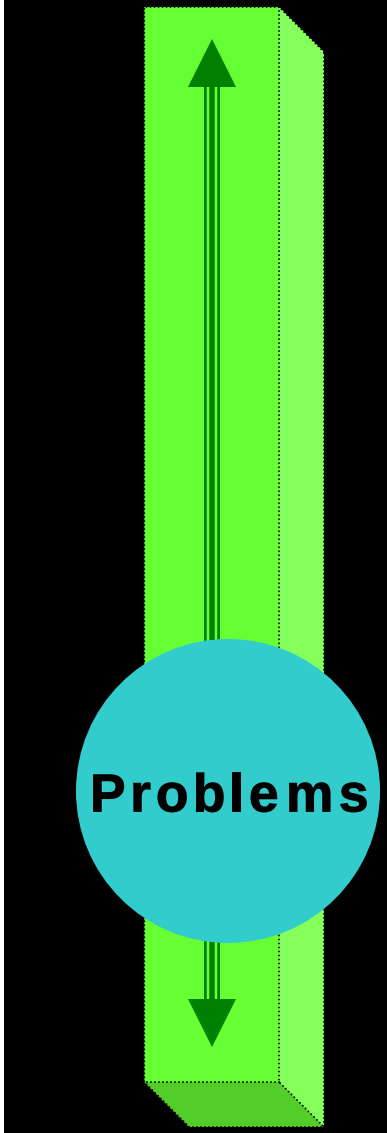
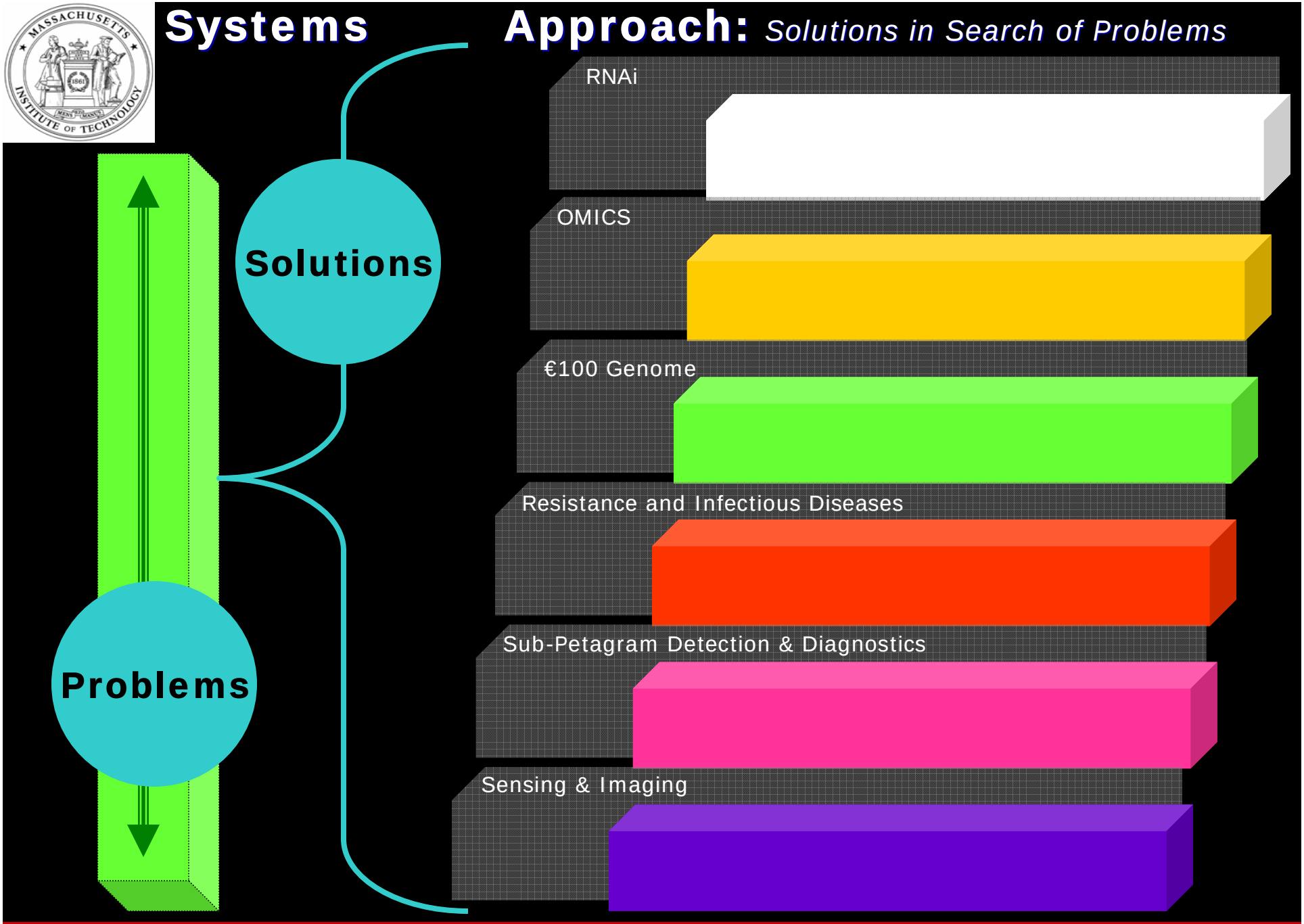
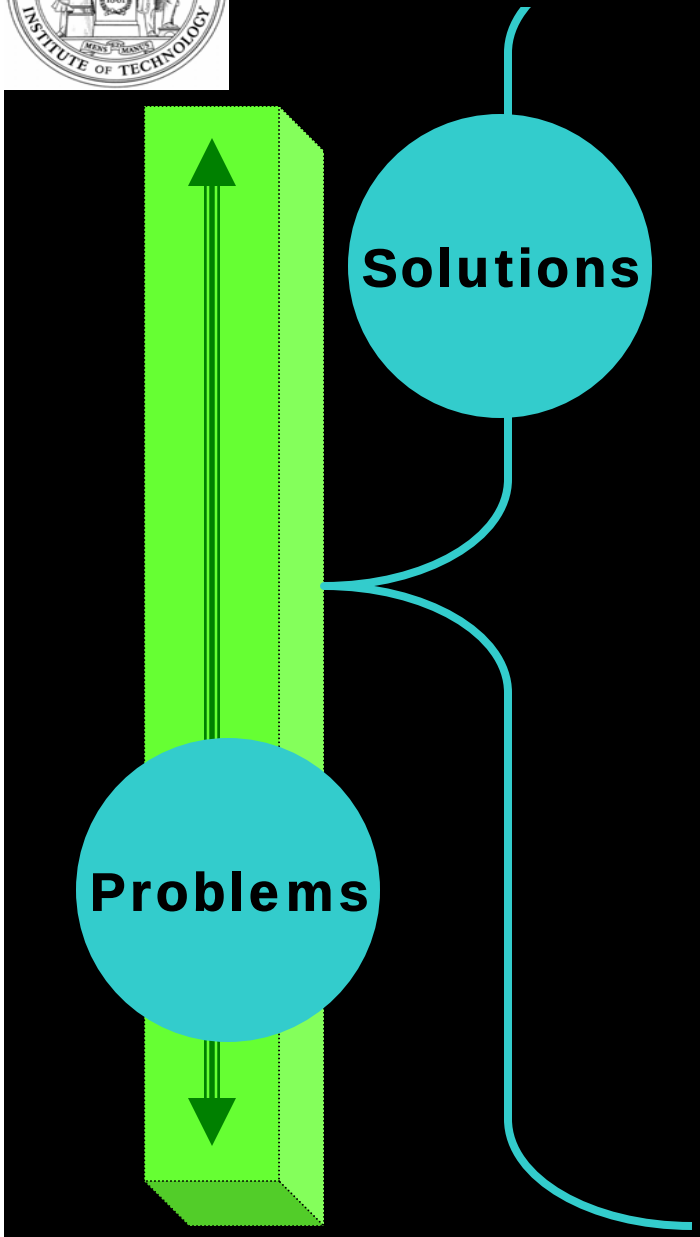


Systems Approach: *Solutions in Search of Problems*



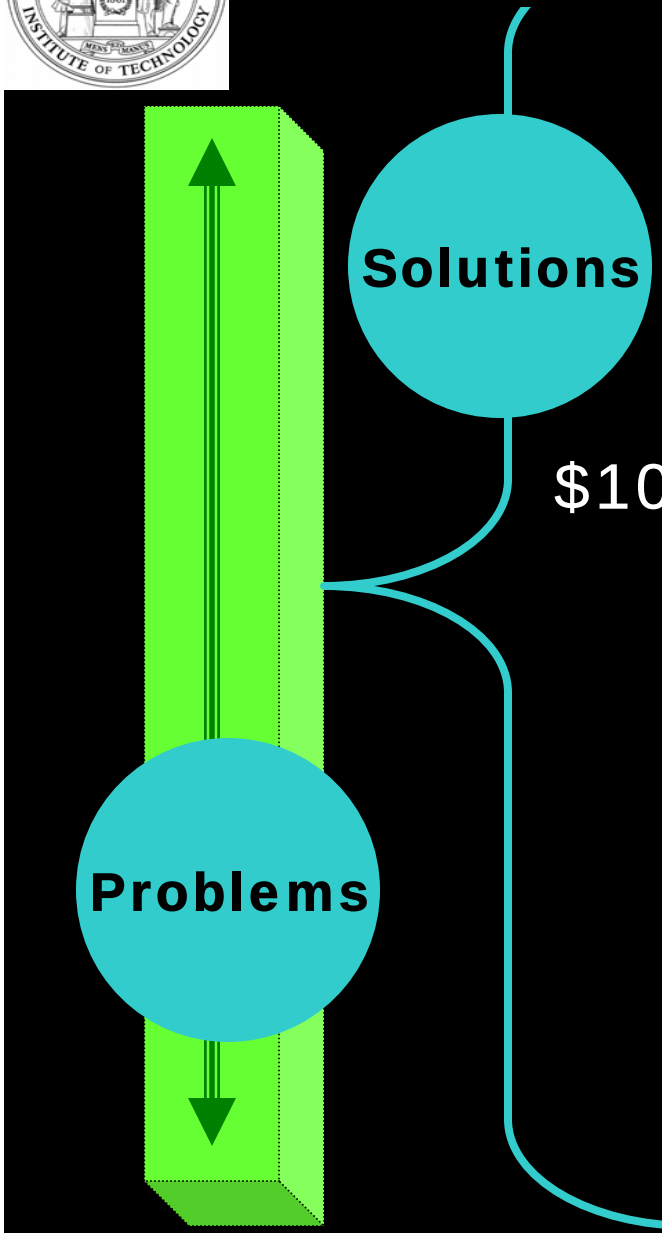
Globalization Changed Market Economics



Median Age 2015
China ~ 45
India ~ 25

Population 2025
1.5 billion each

Globalization Changed Market Economics



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$1000 solutions for 1 million = $1 billion

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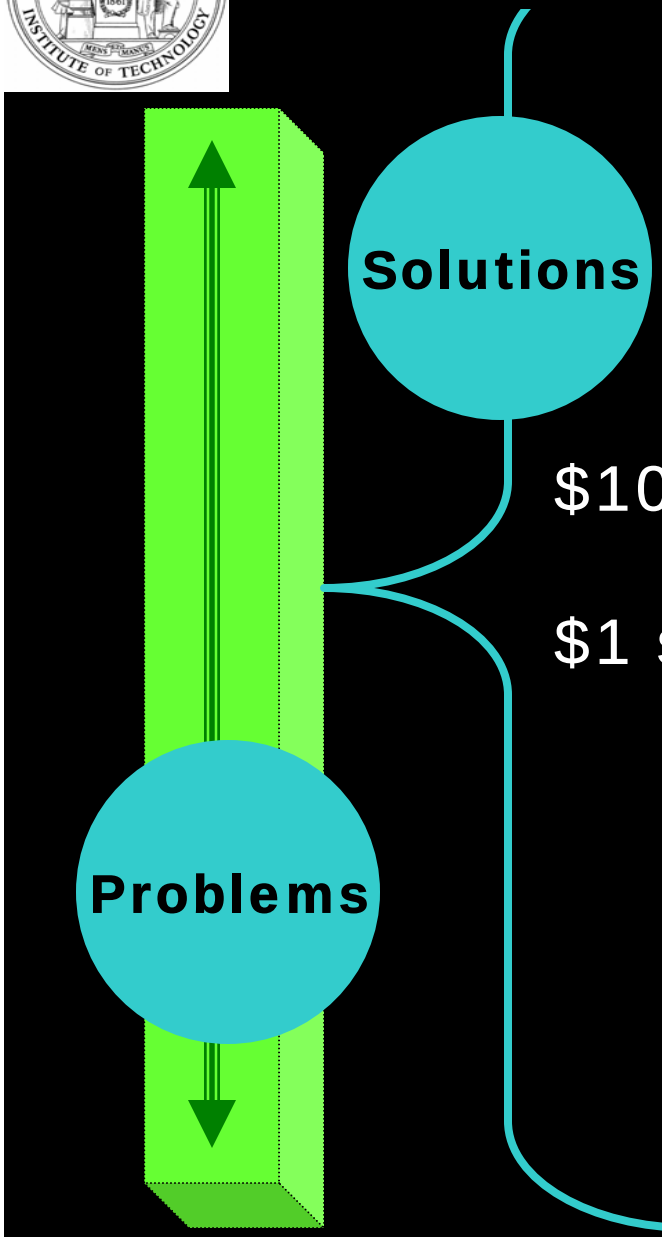

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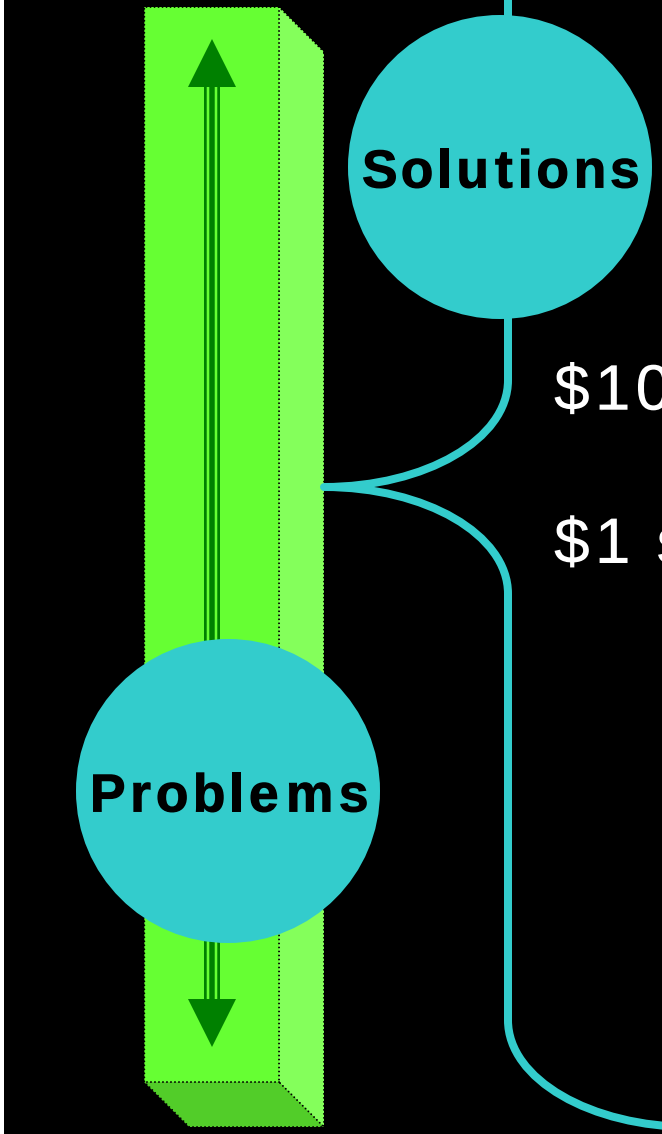

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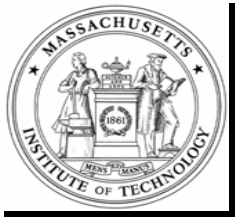
Micro-payments

Nobel Prize 2007
Micro-finance for Women

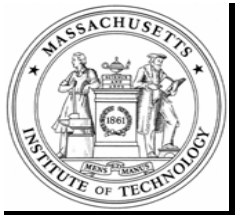


Globalization Changed Market Economics

Globalization could also change the Economics of Philanthropy

Globalization: Economics of Philanthropy

Money Penny: Entrepreneurial Charity Fund Raising

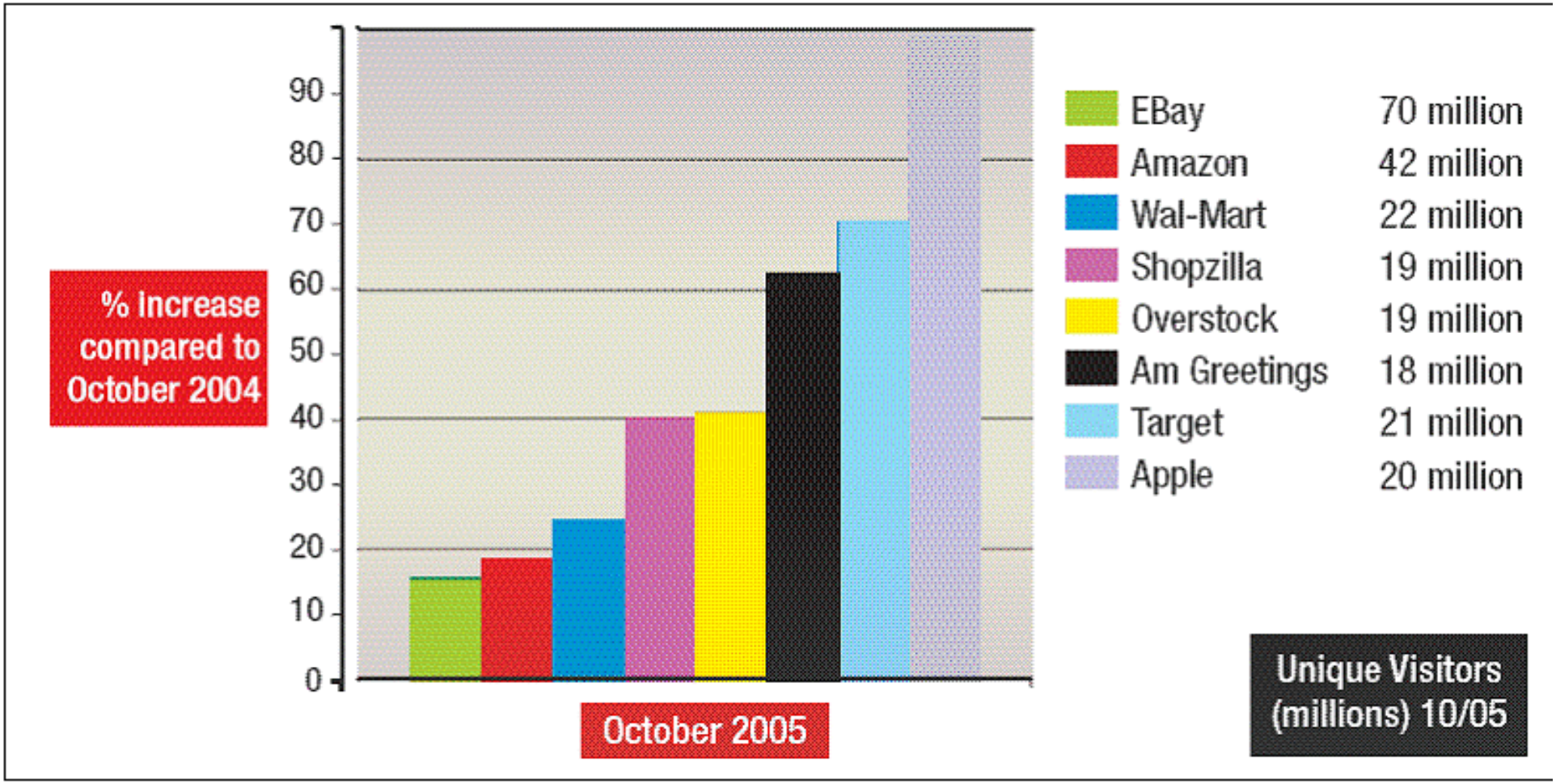


Globalization: Economics of Philanthropy

Money Penny: Entrepreneurial Charity Fund Raising

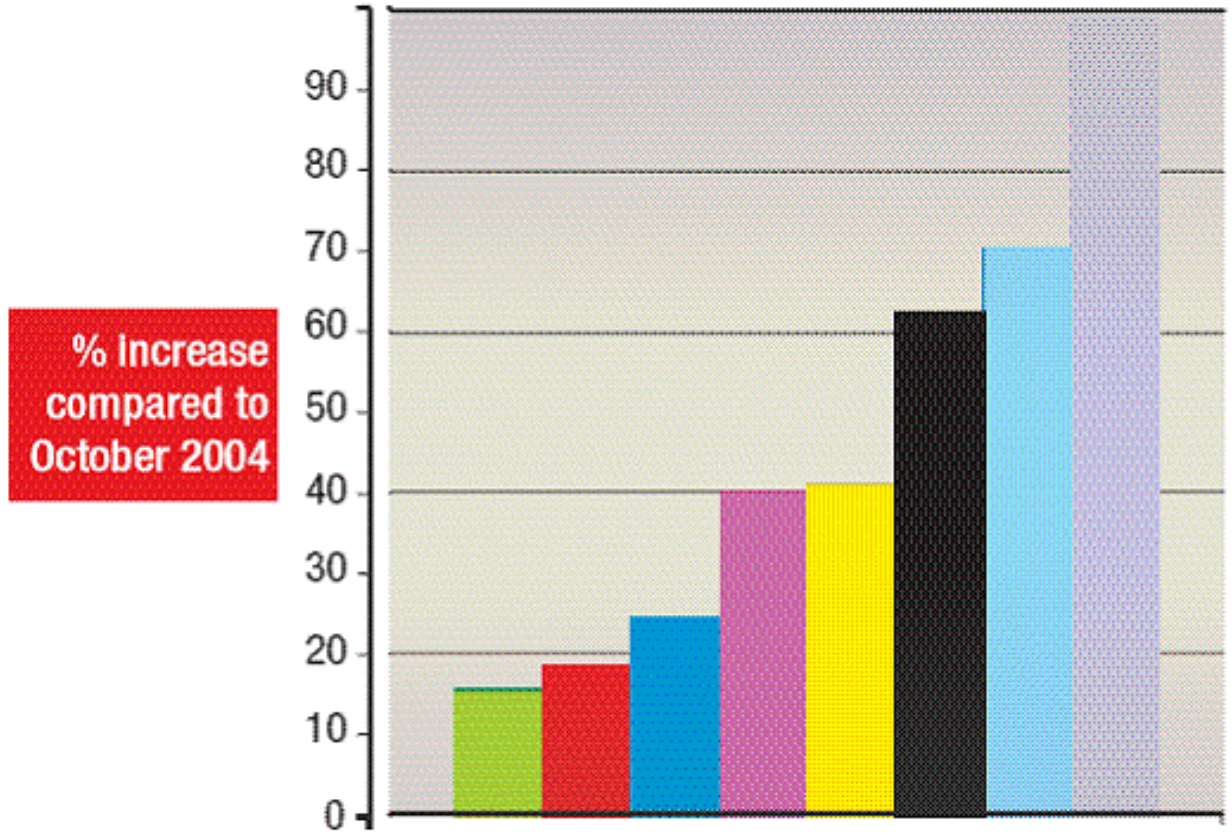
Micro-payments

Globalization: eBusiness



Globalization: eBusiness

2.7 billion visits pa



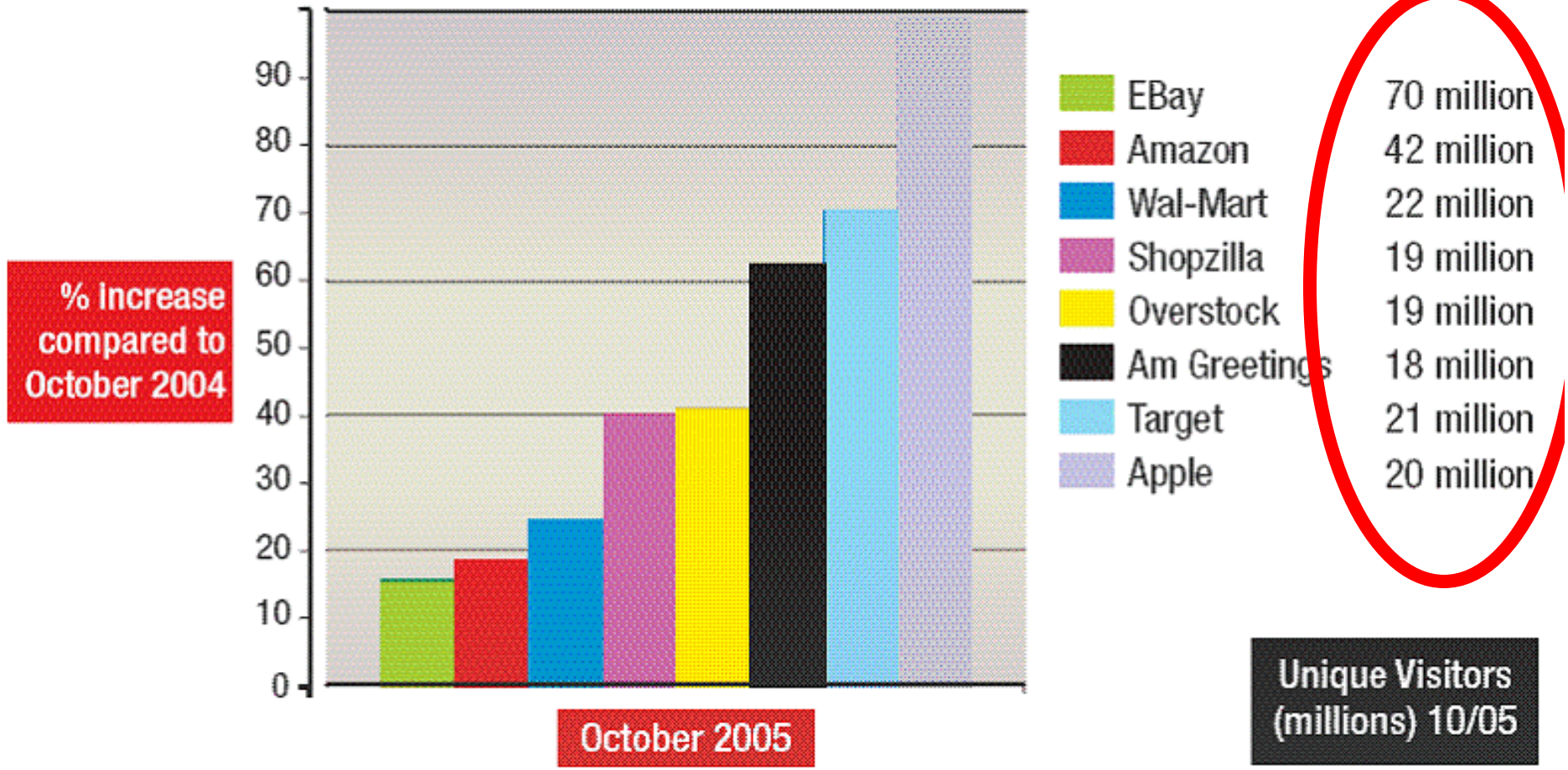
EBay	70 million
Amazon	42 million
Wal-Mart	22 million
Shopzilla	19 million
Overstock	19 million
Am Greetings	18 million
Target	21 million
Apple	20 million

Unique Visitors (millions) 10/05

Globalization: Economics of Philanthropy

Money Penny: Entrepreneurial Charity Fund Raising

Micro-payments 2.7 billion visits pa



Globalization: Economics of Philanthropy

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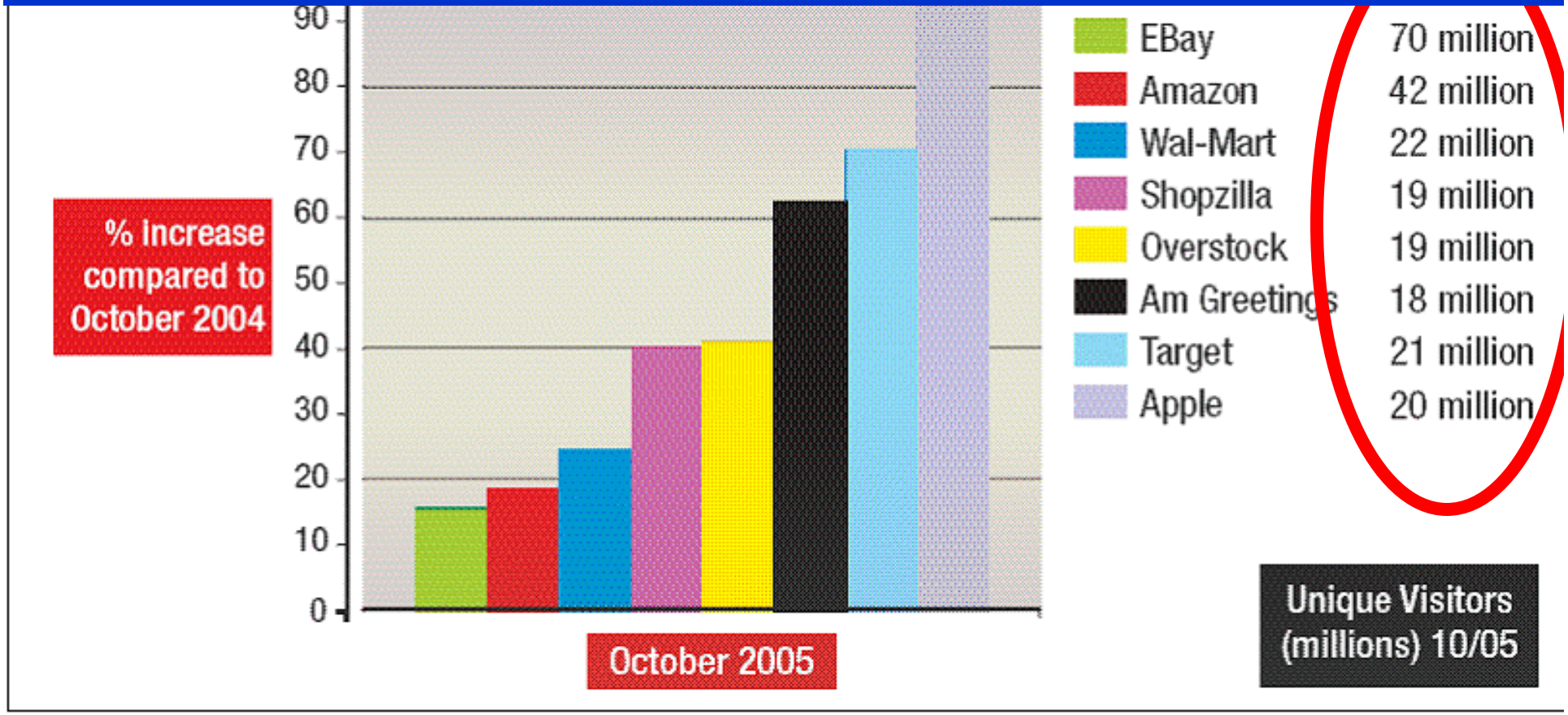
Only 1 cent from 2.7 billion visitors is $27 million



Micro-payments

Only 1 cent from 2.7 billion visitors is $27 million

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- **Medicine and Healthcare**

I invented nothing new. I simply assembled into

a car the discoveries of other men behind

whom were centuries of work.

HENRY FORD

- **ICT**

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- Medicine and Healthcare
- Environment
- Logistics
- Energy
- ICT

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- Environment

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

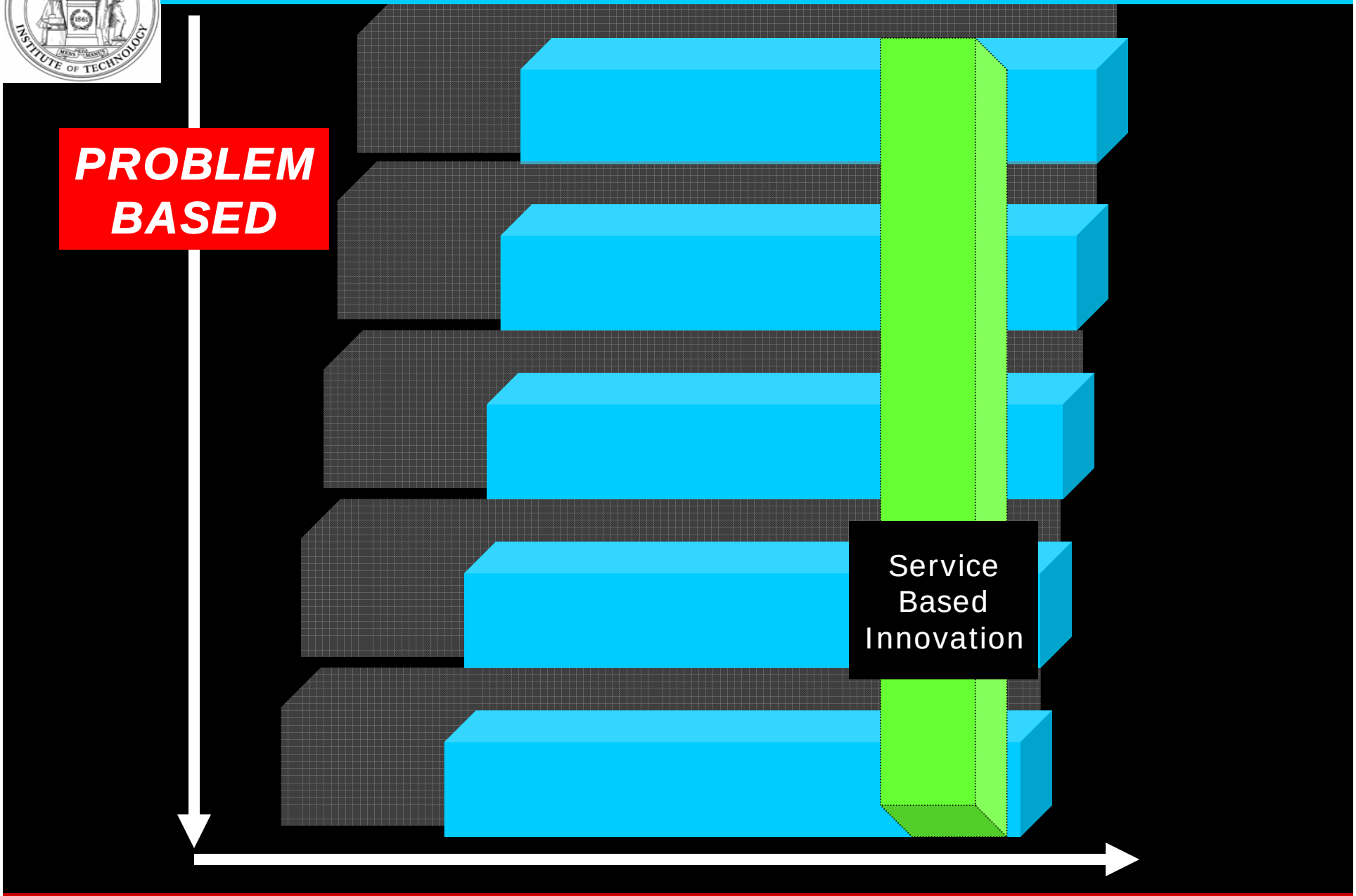
- **Environment**

Galway Contamination

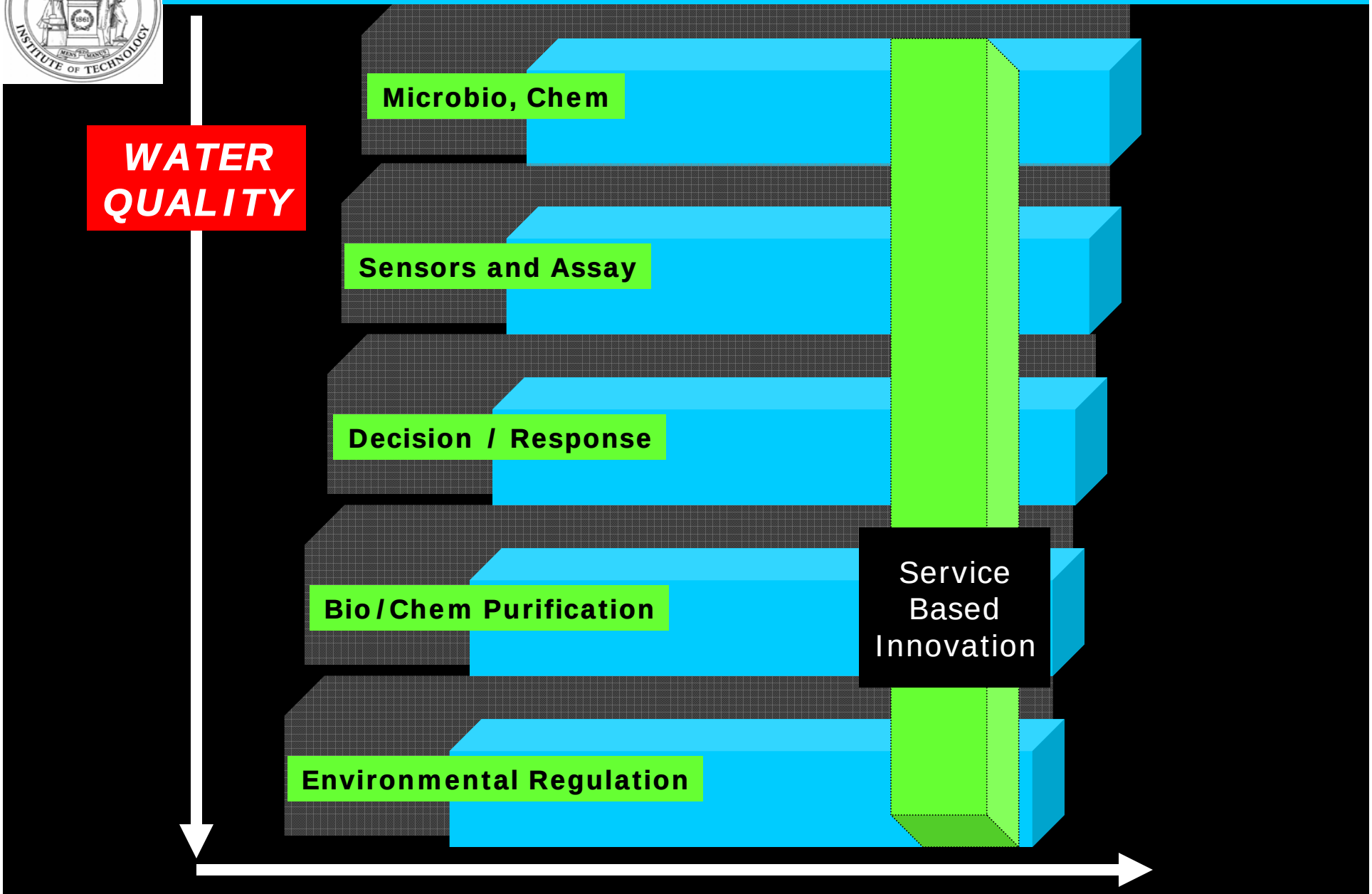
Mayo Leachate

Who's Next ?

Convergence of Innovation: Service Based

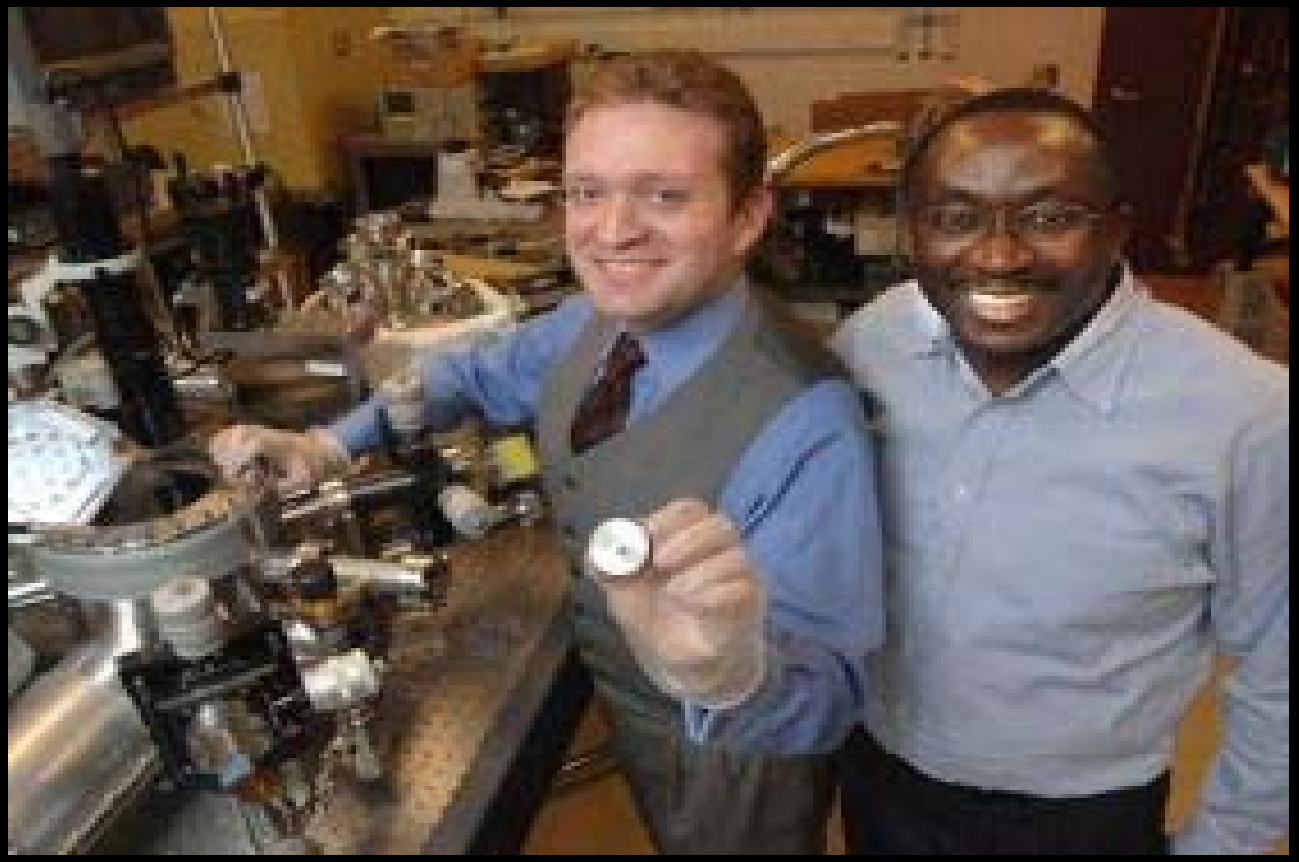


Service Based Innovation: Immediate Use



Environment, Agriculture, Water, Sewage, Leaks

Sensor and Microanalyzer



Matchbox Size Gas Chromatography & Mass Spectrometer

Professor Akintunde Ibitayo Akinwande, Microsystems Technology Lab, MIT
Dr Luis Velasquez-Garcia, Microsystems Technology Lab, MIT

GC/MS

PerkinElmer Clarus 600 GC/MS

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PerkinElmer Clarus 600 GC/MS

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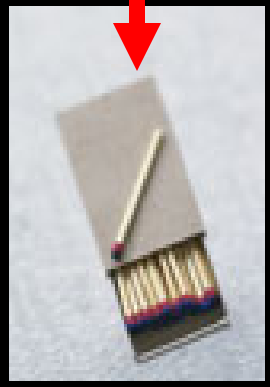
GC/MS in every pocket !!

PerkinElmer Clarus 600 GC/MS



Southern Scientific Ireland
www.southernscientificireland.com

Gas Sensor & Microanalyzer: Matchbox GCMS

Current model is a GAS SENSOR but principle has broad spectrum applcability in detection of trace toxic industrial chemicals including chemical warfare agents as well as remote monitoring of water, air, soil quality analysis and medical diagnostics.

Sensors dispersed in buildings, outdoors, anywhere globally. Data collected globally.

Portable GC-MS takes about 15 minutes to produce results and use 10,000 joules of energy. Current prototype uses 4 joules and produces results in about 4 seconds.

Mechanism:
Analyzer works by breaking gas molecules into ionized fragments, which can be detected by their specific ratio of charge to molecular weight. Molecules are broken apart either by stripping electrons off the molecules, or by bombarding them with electrons stripped from carbon nanotubes. The fragments are then sent through a long, narrow electric field. At the end of the field, the ions' charges are converted to voltage and measured by an electrometer, yielding the distinctive electronic signature.

Manufacturing:
Precision built using micro-fabrication. Batch-fabrication to produce inexpensive sensors for mass use.

Research funded by DARPA (Defense Advanced Research Projects Agency), US Department of Defense and the US Army Soldier Systems Center in Natick, Massachusetts. Collaborators are University of Cambridge and Raytheon.

Source: http://web.mit.edu/ipc/people/faculty/akinwande.html

Gas Sensor & Microanalyzer: Matchbox GCMS

How can it DRIVE economic growth in Ireland?

Gas Sensor & Microanalyzer: Matchbox GCMS

How can it DRIVE economic growth in Ireland?

Southern Scientific Services
Kerry, Ireland
www.southernscientificireland.com

Local services company in collaboration with MIT

may further extends global monitoring with

wireless remote sensors

Services may benefit from GCMS Remote Sensor

Food Auditing
Air Monitoring
Waste Analysis
Site Assessment
Discharge Analysis
Environmental Audits
Pollution Investigation
Ecological Assessments
Contaminated Land Assessment
Analysis of water, soil and effluent
Agricultural analysis (phosphates, nitrates)

www.southernscientificireland.com

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- Logistics & SCM

Spain and Morocco: Next Logistics Revolution

Spain and Morocco: Next Logistics Revolution

13 km: Bridging Africa to Eurasia

13 km: Bridging Africa to Eurasia

Pragmatic Vision: Not Tunnel Vision

8 mile Tunnel: Cape Town to Shanghai

8 mile Tunnel: Cape Town to Shanghai

Kouvola to Vladivostok: TRANS-SIBERIAN RAIL

Tri-Continental Logistics

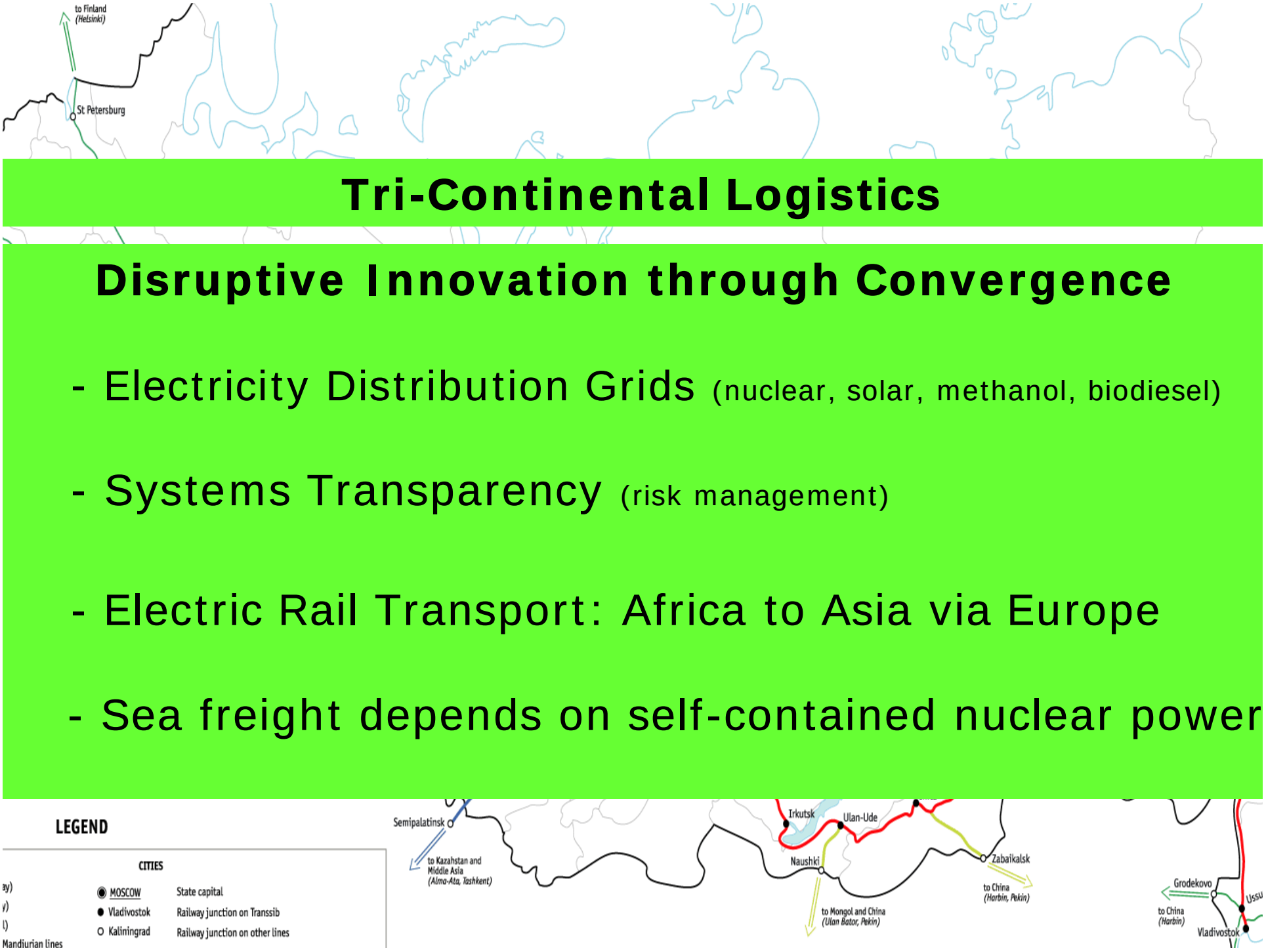
Disruptive Innovation through Convergence

- Electricity Distribution Grids (nuclear, solar, methanol, biodiesel)

- Systems Transparency (risk management)

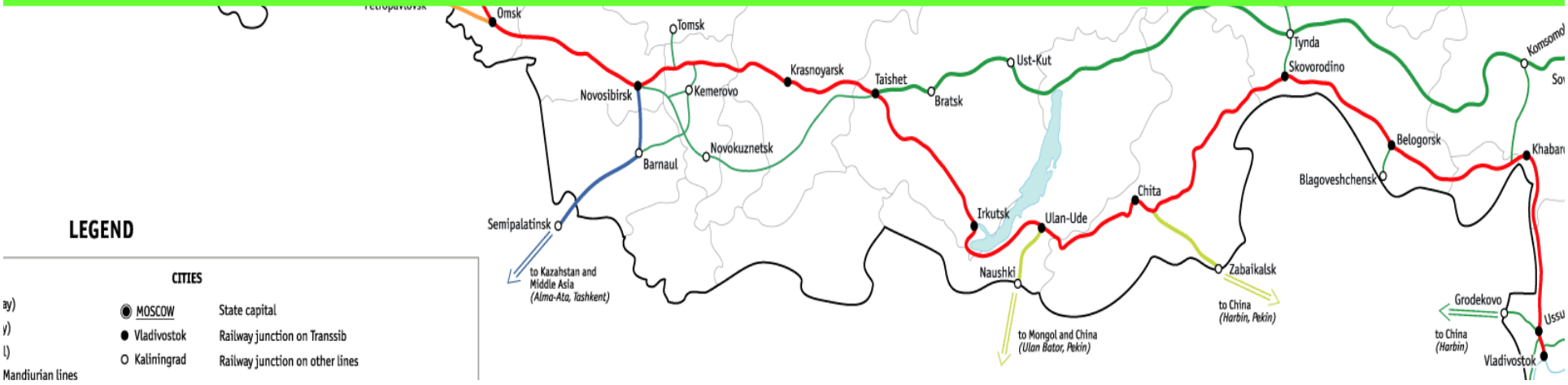
- Electric Rail Transport: Africa to Asia via Europe

- Sea freight depends on self-contained nuclear power



Kouvola to Vladivostok: Systems Visibility & Risk

- Disruptive Innovation in Global Supply Chain
- Analytic Conversion of Data to Useful Information
- Systems Understanding of Decisionable Information



DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

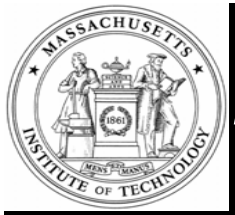
- Energy

FDI : Alternative to US Treasuries/Securities

Source: PFC Energy Report on Saudi Arabia, Iran, UAE, Kuwait and Qatar (revenues)

2000 year-ending total foreign assets	estimated $450 billion
2006 year-ending total foreign assets	estimated $900 billion
2006 revenue from sale of hydrocarbons	estimated $250 billion
? Annual Investment Capital (revenue - infrastructure investment)	estimated $100 billion

Business transparency a catalyst for globalization of capital investments?



Road to Hydrogen: Corn, Sugarcane, Sorghum, Jatropha

USA
>21 million barrels per day or ~8 billion barrels pa (petroleum)
(60% imported) >25% world consumption
Ethanol production ~4 billion gallons

Canada
~170 billion barrels in Fort McMurray (Alberta) active ~25 years (2025)
(<20 years supply for US at current rate of consumption – unrealistic)

Brazil
Ethanol >40% of transportation fuel (current production >3 billion gallons)

China
Ethanol export negotiations with Brazil
Fort McMurray to Vancouver pipeline negotiations
25% of Russian gas reserves : pipeline negotiated

- ***Irrigation & Agriculture***
- ***Production & Distribution***
- ***Automobile Engine Compatibility***

Convergence

Oil Crisis Mitigation Strategy: S. cerevisiae; Catalysts; Jatropha

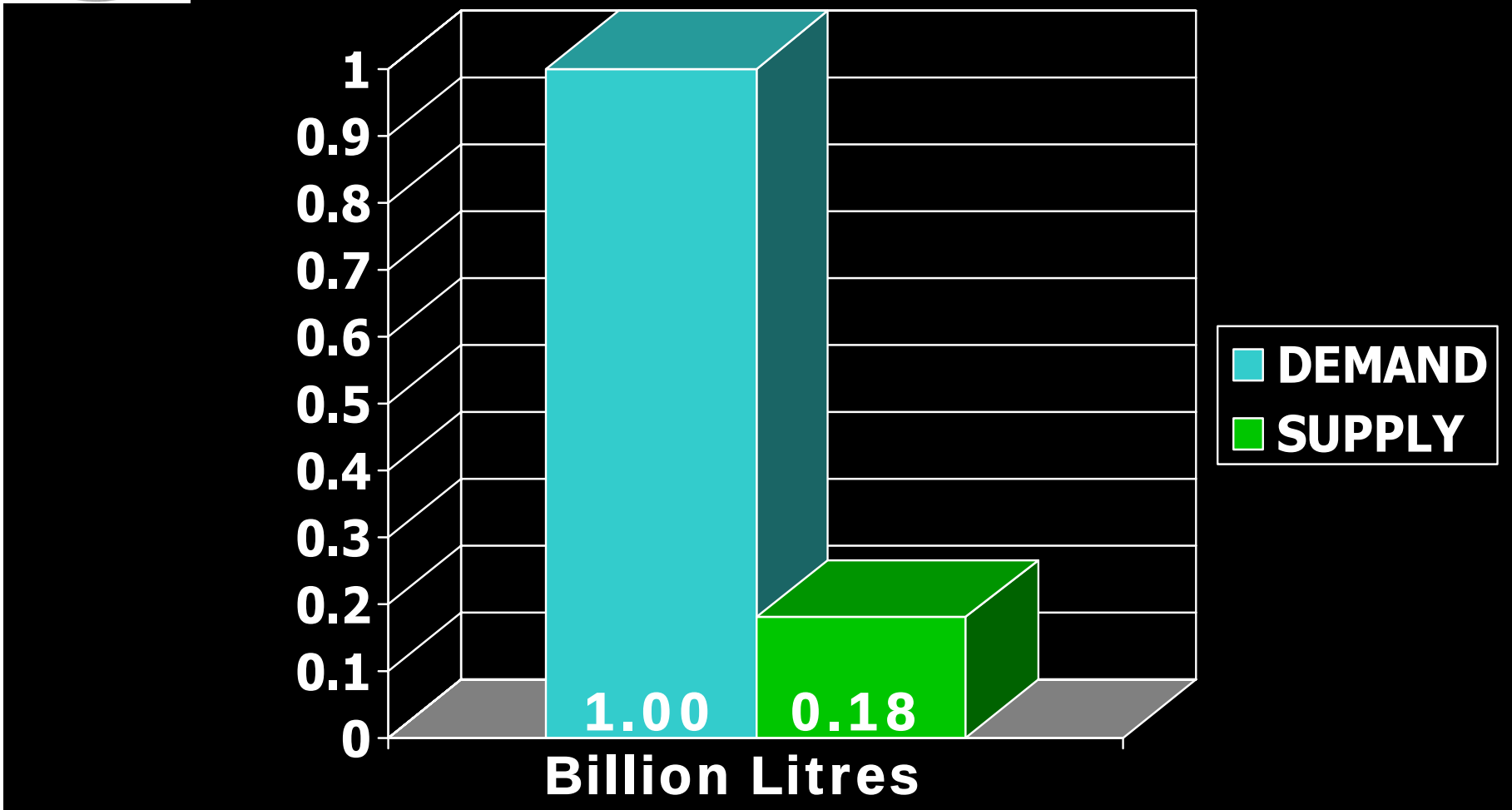
Biofuel Sources in India

- **Ethanol**
  - **molasses, beet, sweet sorghum, sugarcane**
  - **cellulosic (wood, grass, biomass residue)**

- **Vegetable oils (non-edible)**
  - **Jatropha curcas**
  - **Karanjia**

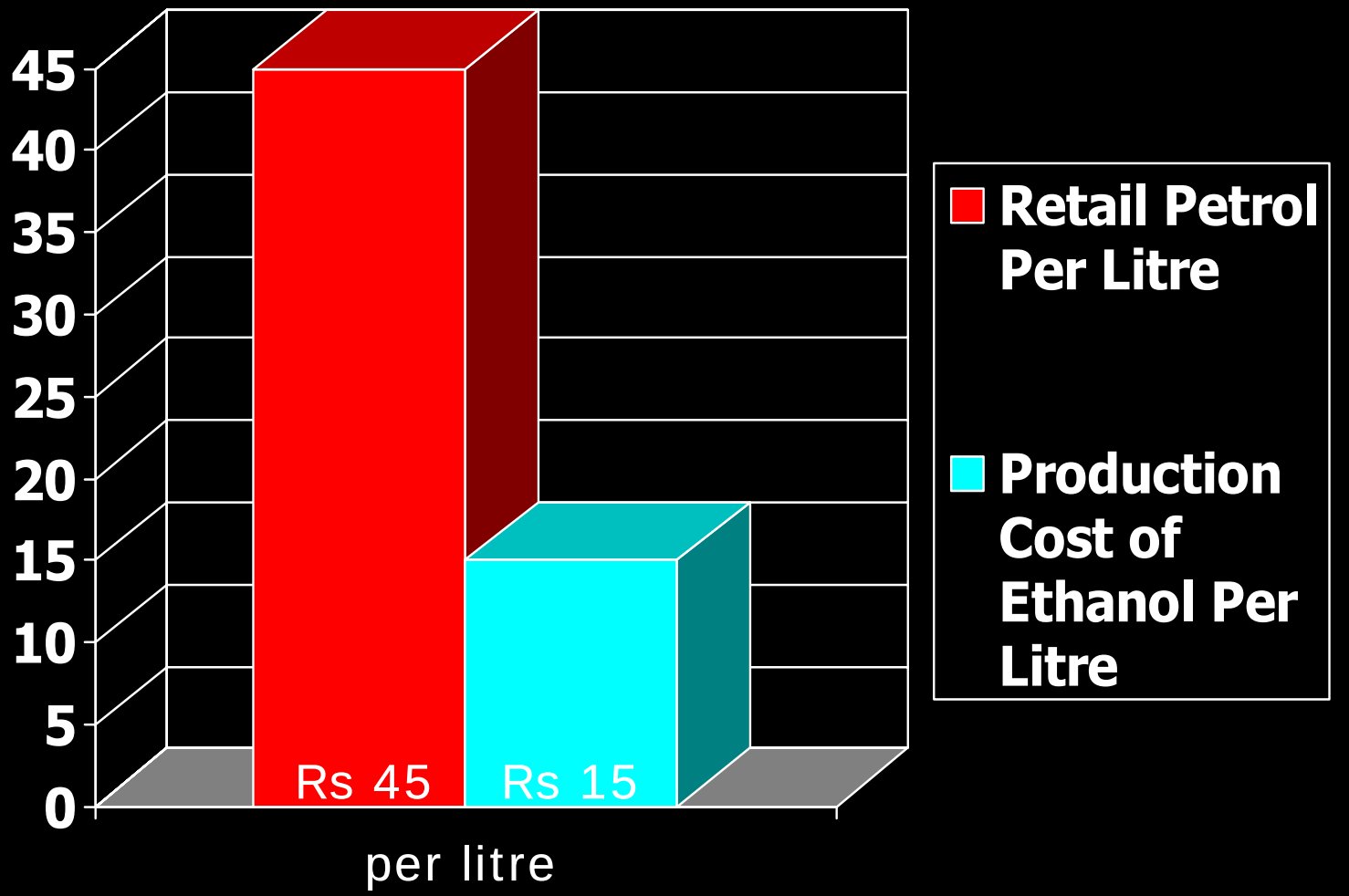
Biofuels in India

Ethanol Demand vs Supply



Data per Government of India. According to the US Department of Commerce, the current demand for ethanol in India is 3.6 billion litres or 3,600 lakh litres.

Price of Petrol vs Cost of Ethanol



Biofuels: Bridge to Hydrogen Economy

Number of automobiles 2005 (60% 2-wheelers)	> 60 million
New vehicles registered (50% 2-wheelers)	~ 10,000 per day
Actual Petrol consumed by automobiles	10 billion litres per annum
Total Petroleum consumption in 2006	>130 million tons of crude
Diesel consumption	40 million tons
Imported petroleum	80%
2035: Fuel consumption by on-road automobiles *	60 billion litres
2035: Demand for Ethanol @ 10% (90EBG)	6 billion litres
Biomass residue (cellulose from crops & plantations)	> 500 million tons per year
Potential for Cellulosic Ethanol (200 litres per ton)	> 200 billion litres per year
Potential for power generation from biomass	> 50000 MegaWatts per year

* Projected by the Asian Development Bank

Status of Ethanol Use in India

- IOC R&D undertaken detailed studies using ethanol blended gasoline (EBG) including 5% (95EGB) and 10% (90EBG) for commercial use.
- Ethanol blended gasoline mandatory in many states and 90EBG approved on 1 October 2003
- Adequate supply of ethanol is not available

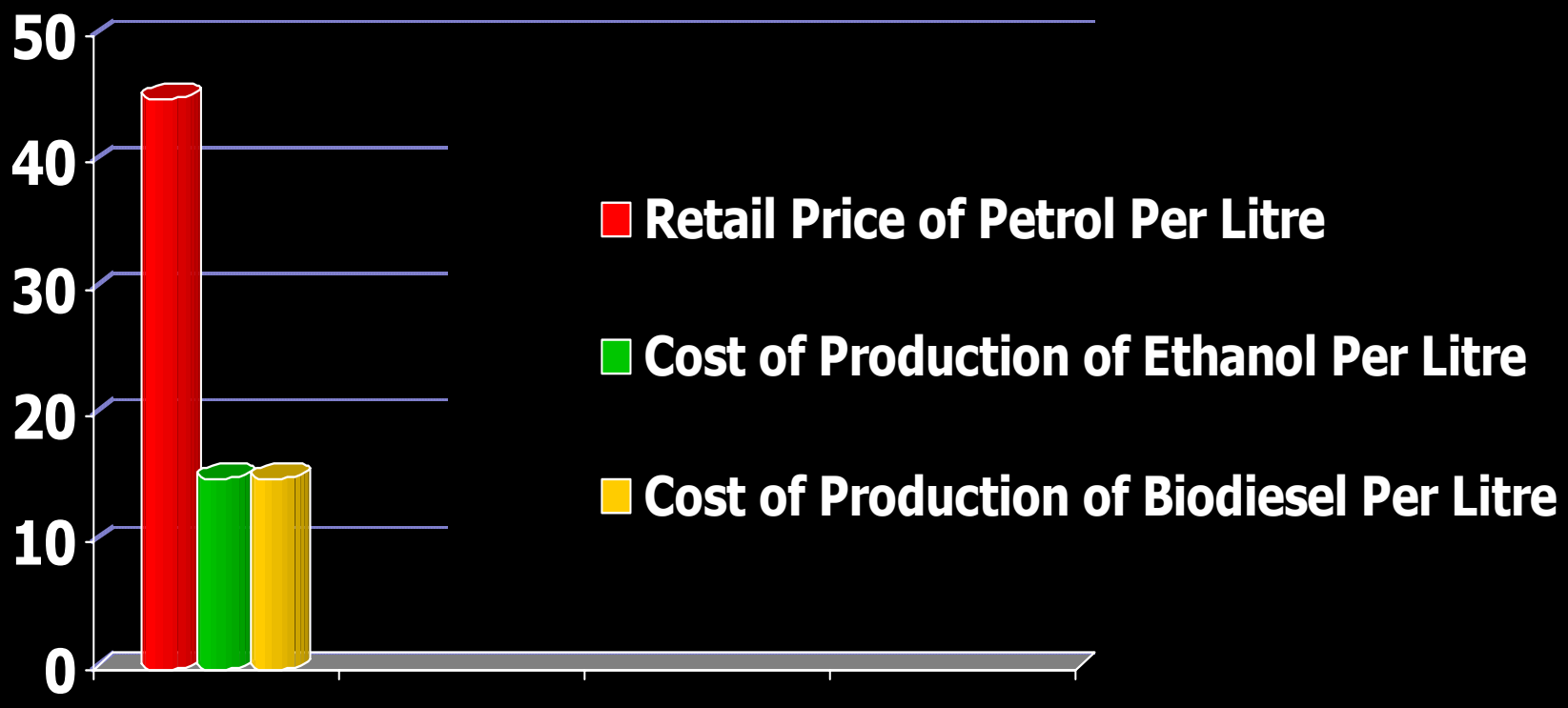
Status of Ethanol Use in Brazil

- 360 million tons sugarcane from 5 million hectares producing 500,000 jobs on plantations and 500,000 jobs in production
- 25,000 petrol pumps dispensing Gasoline, EBG and Ethanol (Alcool)
- VW and GM flex-fuel vehicles (FFV) can run on any fuel or any blended fuel (mixtures)
- Brazil-India cooperation MOU signed in 2001

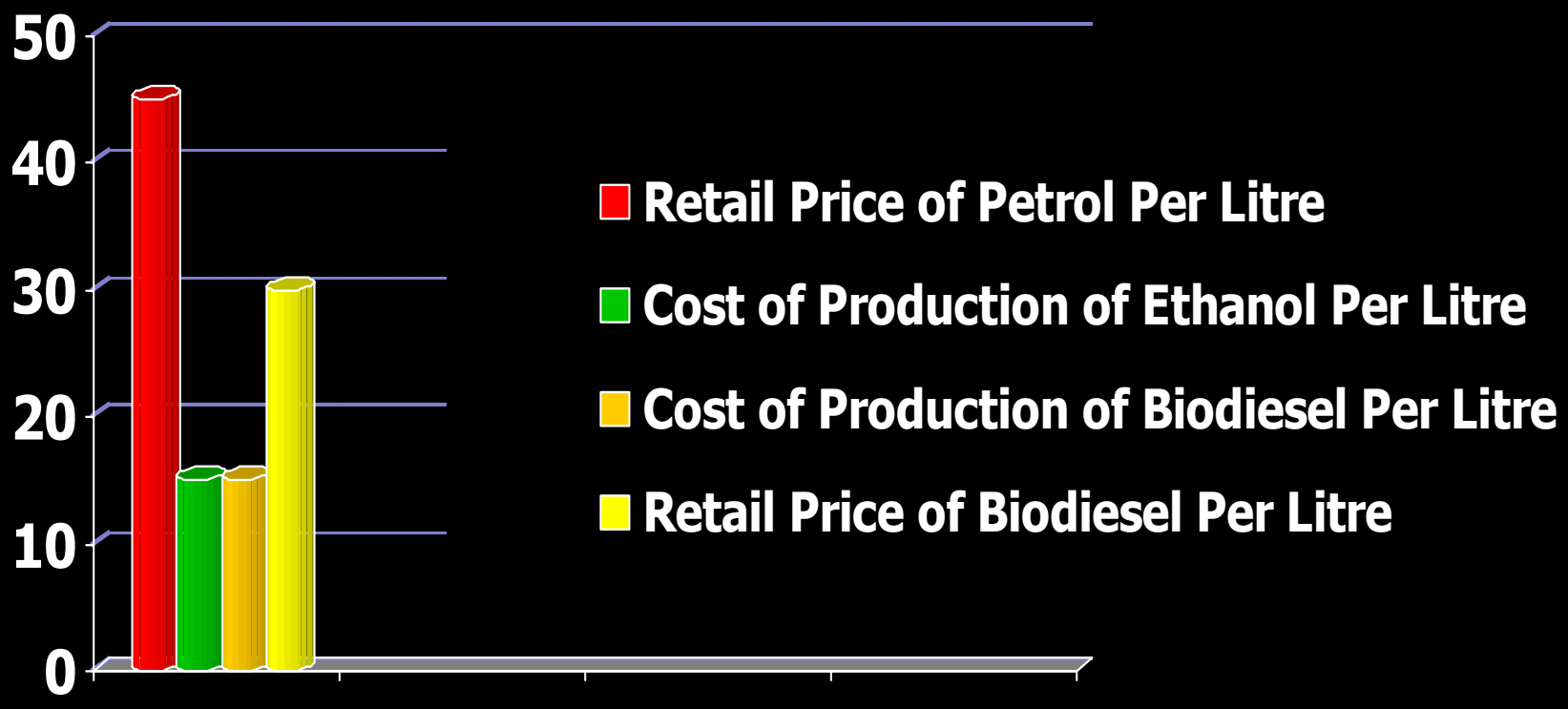
Biodiesel

- Renewable, non-toxic, biodegradable, non-edible vegetable oil
- Lower emissions compared to diesel (zero sulphur, 78% reduction of CO_2 and 50% reduction of CO)
- Better fuel properties (cetane number, lubricity, flash point)
- Daimler Chrysler India successfully tested cars running on 100% biofuel extracted from Jatropha curcas
- 11 million hectares of wasteland suitable for Jatropha cultivation
- 126,000 hectares adjacent to railway tracks owned by Indian Rail

Price of Petrol vs Cost of Biofuels



Rs 30/L **Biodiesel: Profit/Hectare ~ Rs 25,000**



Biodiesel: Profit & Jobs

Lifecycle of plant	50 years
Oil content of seed	35%
Oil yield / kg of seed	250 ml
Plants / hectare	2,500
Job creation / hectare	0.25 FTE
Cost of maintenance / hectare / year	INR 20,000
Seed yield / hectare / year	7 tons
Oil yield / hectare / year	1750 litres
Cost of oil production / litre	INR 15
Cost of oil transport to Europe / litre	INR 5
Cost of oil production / hectare	INR 26,250
Pressed seedcake / hectare	4.5 tons
Selling price of seedcake / ton	INR 4,000
Cost of oil production & maintenance / hectare	INR 46,250
Sales of oil @ INR 30/L and seedcake / hectare	INR 70,500
Gross earnings from biodiesel / hectare	INR 24,250
Area adjacent to railway tracks (hectare)	126,000
Earnings from biodiesel from 126,000 hectares	INR 30 CRORES
New job creation from use of 126,000 hectares	30,000
Wasteland	10 million hectares
Earnings from biodiesel per million hectare	INR 2,425 CRORES
New job creation per million hectare	250,000
Potential for new job creation from Wasteland	25 LAKHS

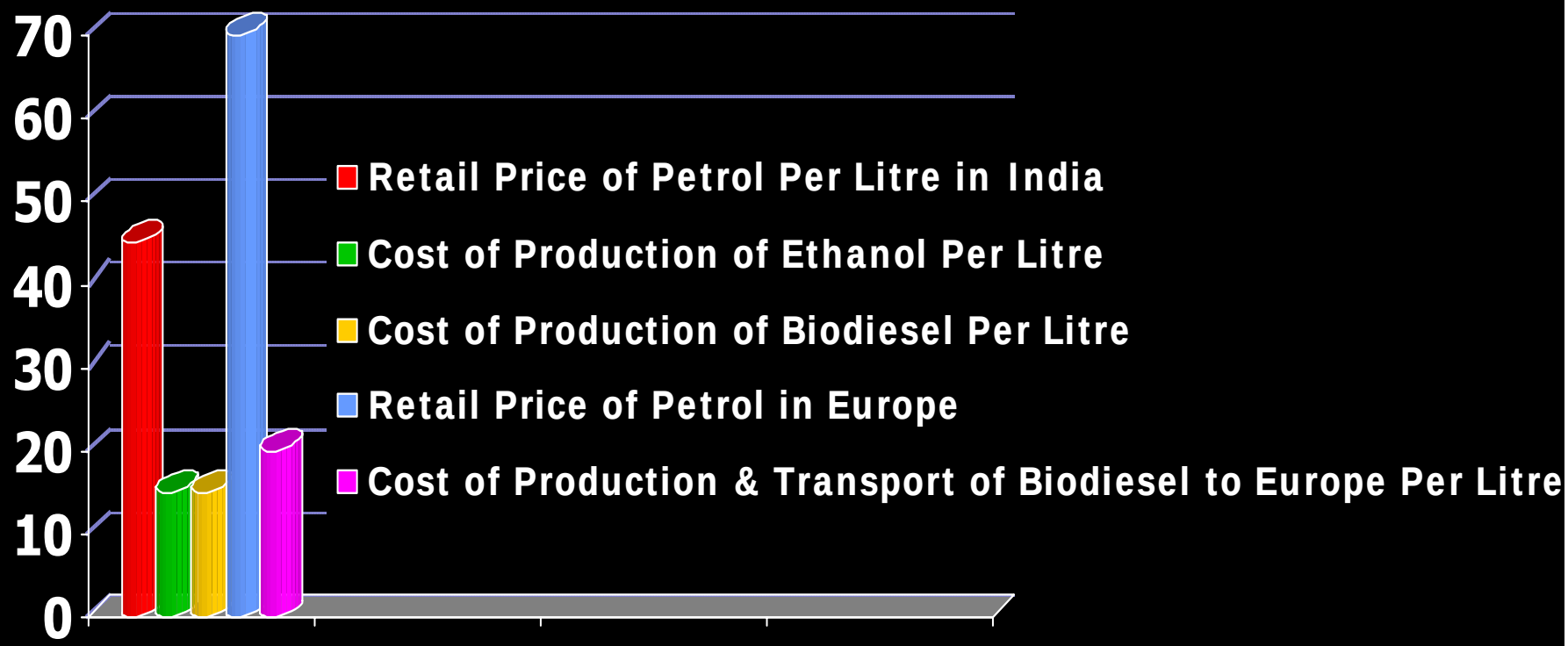
IOC, Indian Railways, Tata & Other Initiatives

- Trans-esterification, process optimization and commercialization
- Testing of locomotive engines with biodiesel (B100) and blends
- Vehicle performance and emission studies (Escorts, Tata, M&M)
- Field trials with buses in Gujarat
- Jatropha plantation on 70 hectares adjacent to rail tracks
- Studies on 16 cylinder engine (3100 hp) with B5, B10 and B20
- Shatabdi & Jan Shatabadi Train trial runs
- Trains through Lucknow using bio-diesel (B10) from June 2006
- Evaluation of B20 for 4 passenger cars and 2 commercial vehicles
- Tata Motors employee buses using B10 in Pune
- Haryana Roadways converts entire Gurgaon bus depot to use B5

Biodiesel Purchase Policy (9 October 2005)

- Biodiesel policy involves PRIs for Jatropha plantations and oil extractions by establishing Rural Business Hubs
- OMC purchase price INR 25 per litre.
- Assistance for Jatropha plantation and oil extraction.
- IOC R&D to increase biodiesel content from 5% to 20%

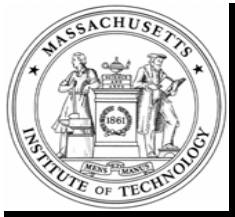
Profit from Export of Biodiesel



February 2006:
BP invests $9.4 million in India for Jatropha biodiesel.

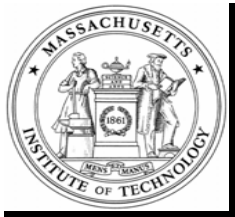
China: Biofuel Boom

- 13 million hectares for Jatropha plantation
- 200,000 tons of biodiesel by 2010
- 1 billion litres of Ethanol produced in 2006
- Production cost for cellulosic ethanol $0.25 / L



Before Hydrogen: Methanol

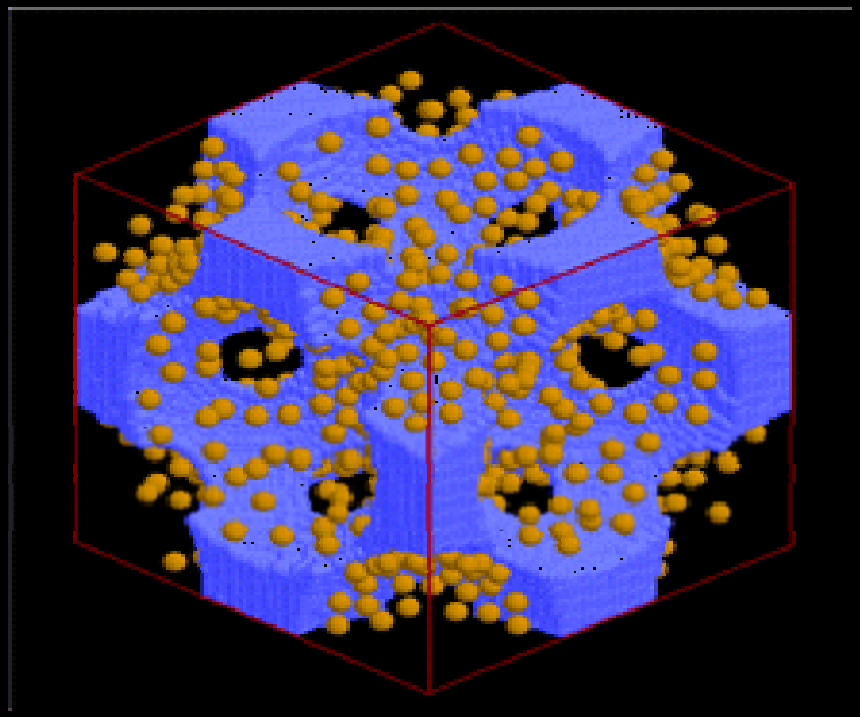
- Fischer-Tropsch Process
- Methanol Economy
- George Olah, Nobel Prize in Chemistry



NanoLetters (2004) **4** 1489-1492

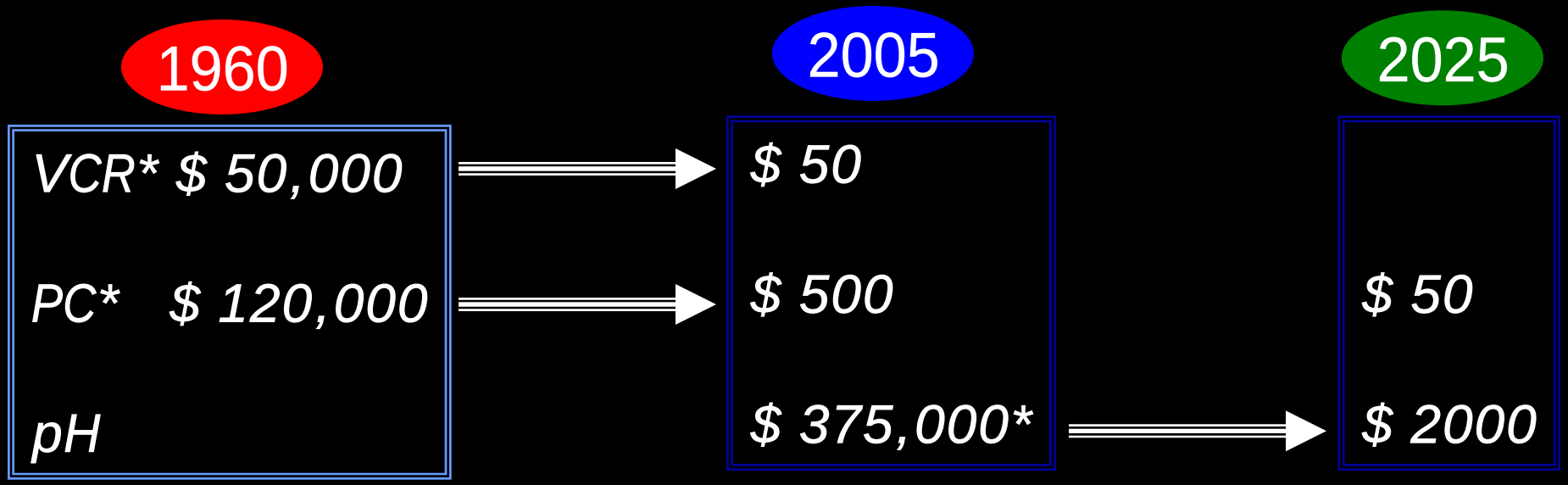
Hydrogen

Molecular Simulation of Novel Carbonaceous Materials for Hydrogen Storage



Snapshot of hydrogen molecules adsorbed in the GCIO porous material. Carbonaceous material indicated in blue and yellow spheres represent Hydrogen.

Portable Hydrogen Plant in Every Garage



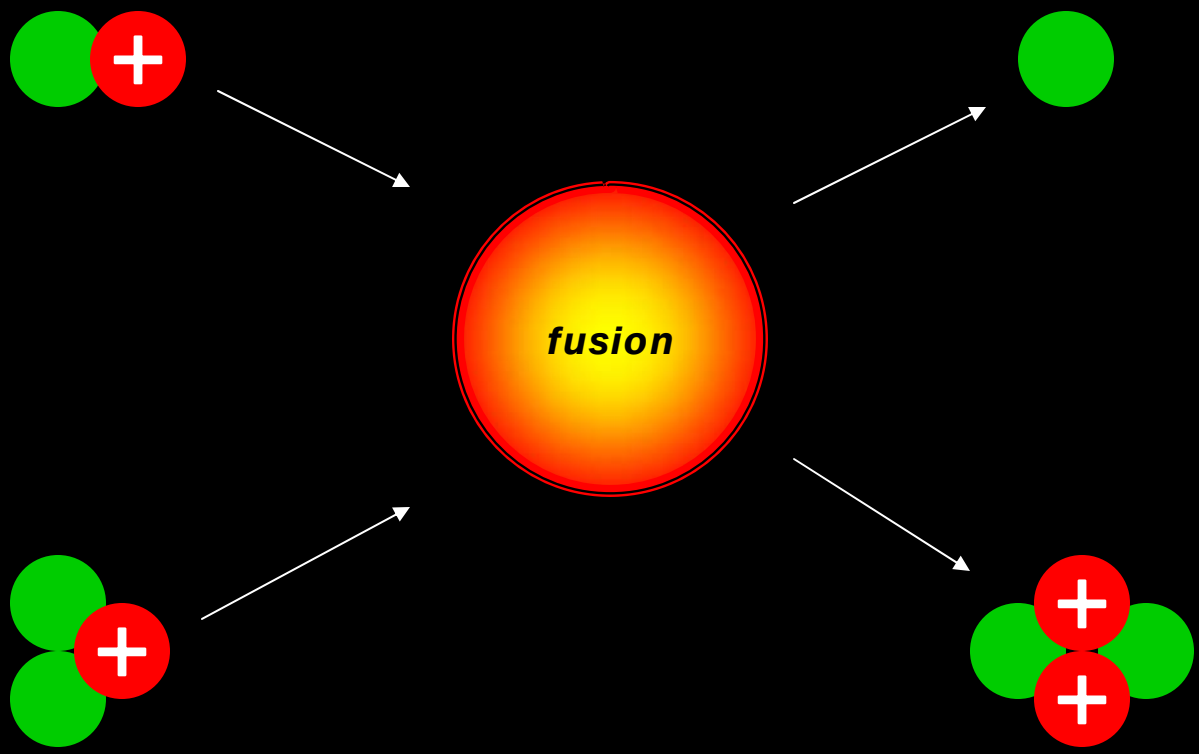
* Cost of semi-portable Hydrogen generator from natural gas (www.auto.com/industry/hfuel5_20030305.htm)

* VCR manufactured by AMPEX Corporation; * Desktop PC model PDP-1 manufactured by DEC

A chicken in every pot and a car in every garage!

Herbert Hoover 1928 (1929-1933) 31st POTUS

After Hydrogen: Fusion



- Energy in your cupboard

Renewable Innovation

Metabolic Engineering

Engineer bacteria to produce petroleum substitutes

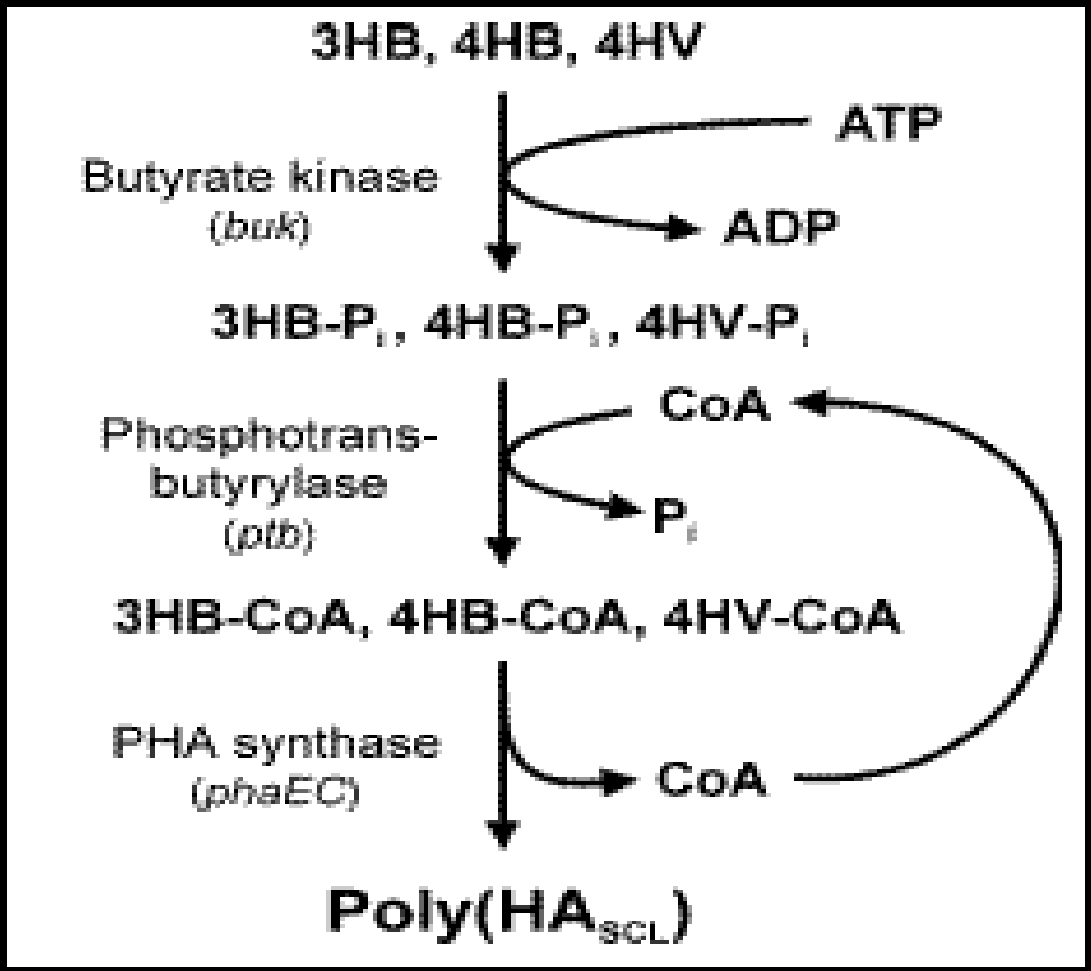
Renewable Innovation

Metabolic Engineering

Non-natural biosynthesis

Polyhydroxyalkanoic acid

Prokaryotic carbon store

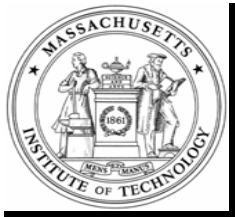


Steinbuchel, 2003. Biochemical Eng J **16** 81-96

DRIVE Convergence of Innovation

PRODUCTS & SERVICES EXAMPLES:

- ICT



CONFLUENCE ... The 100 year vision

Agnostic Confluence of Concepts, Technologies, Standards

TOOLS

Operations Research, Game Theory
Econometrics (MGARCH)
Transaction Cost Analysis (TCE)
Autonomous Agents, Distributed AI
Semantic Web, Models, Language
Web 2.0, Web X.0, Grid Computing
Simulation, User Interfaces (TUI)
Streaming Database, Clockspeed
Functional MRI

Systems 2000

CONVERGENCE

DATA

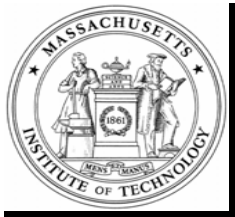
802.11 / WiFi
802.16 / WiMax
802.15.4 / ZigBee
Bluetooth, Mesh, P2P, O2O
Ultrawideband (UWB), RFID
Sensors (MEMS, NEMS)
GPS, RTLS
Software Radio (SDR), 4G
EPC, GTIN, GTAG, UID, UCR
IPv6

Process Innovation

Adaptive → Predictive Decision Systems 2050

Convergence

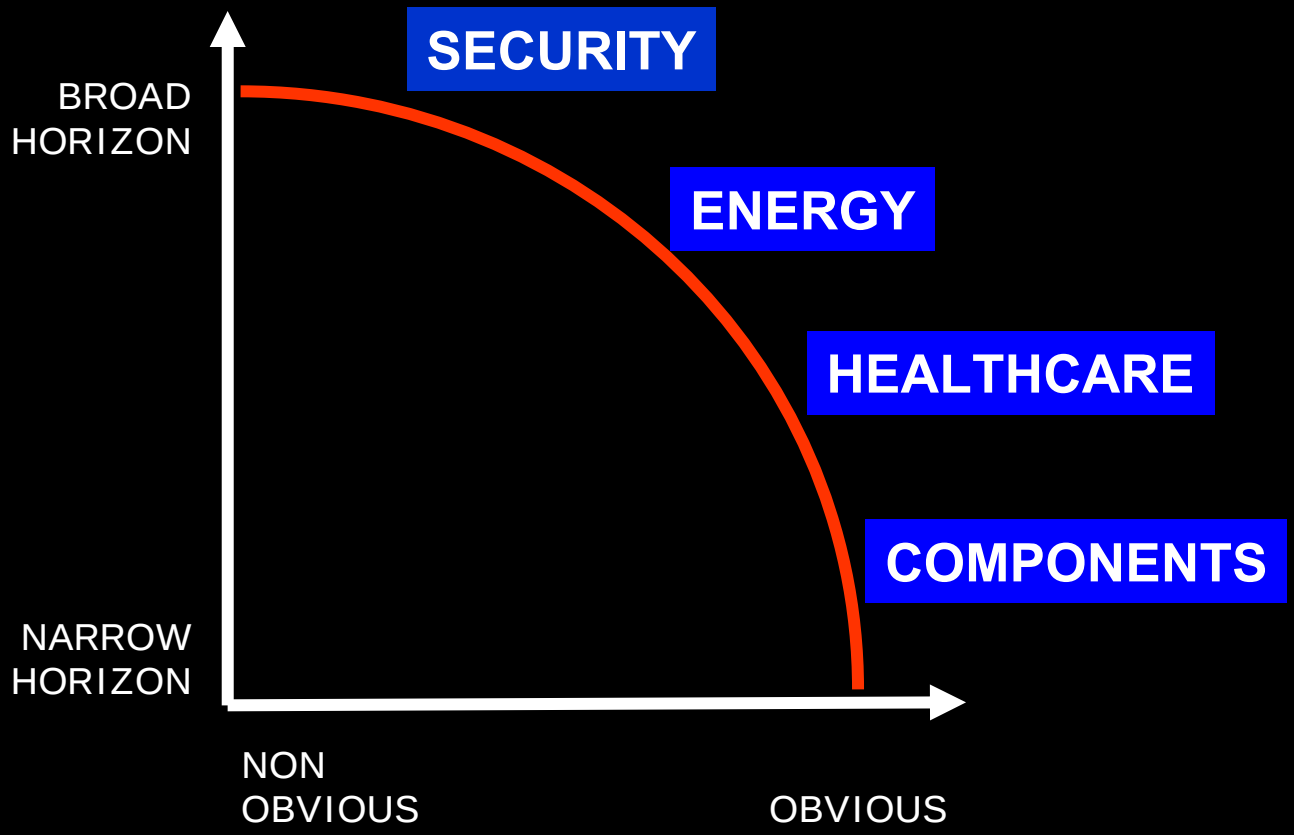
- Decision Systems
  - Obvious Relationships (business, industry, growth strategies)
  - Non-obvious Relationships (risk, security, growth strategies)



The Systems Age

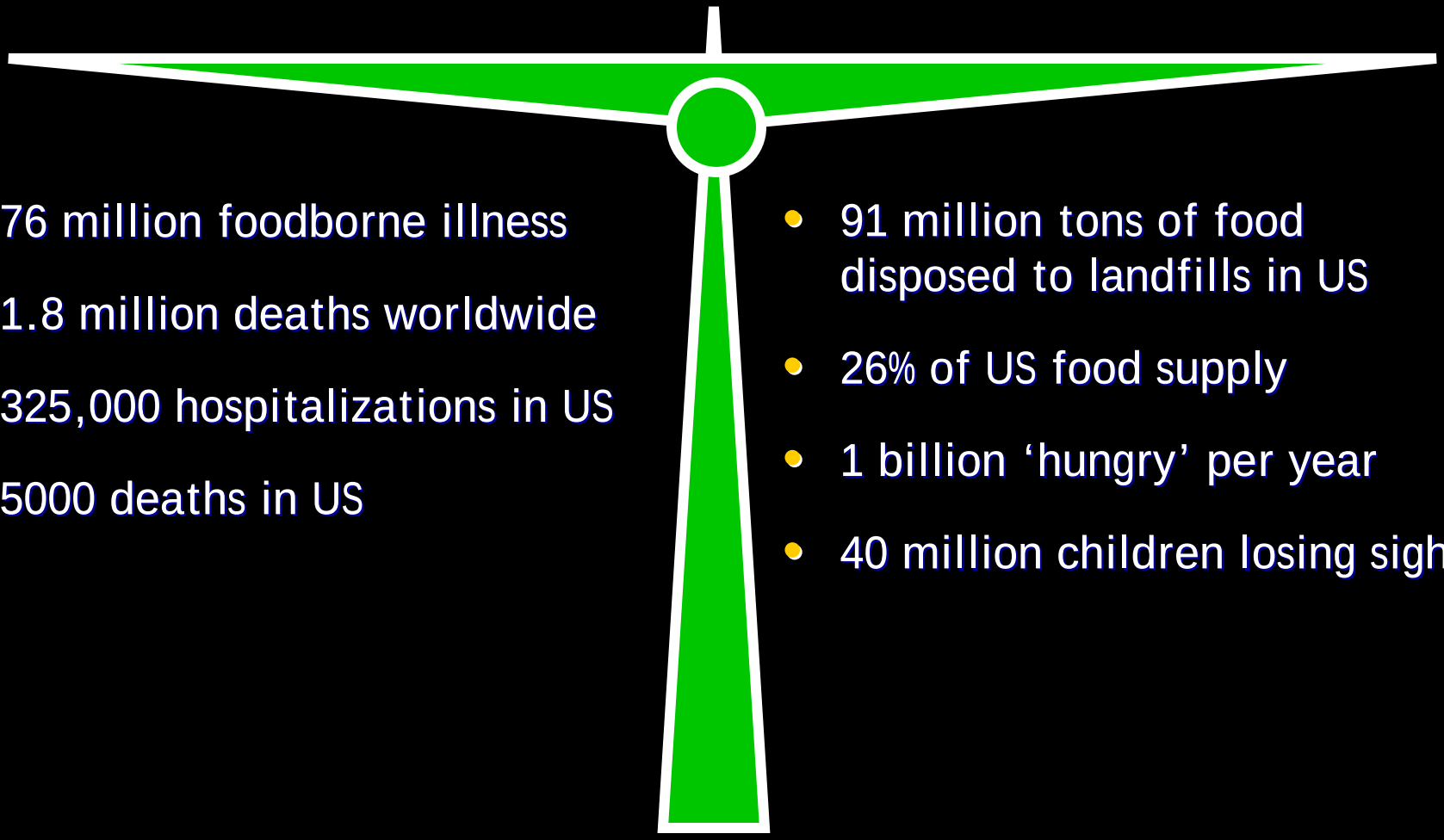
- Interoperability
- Transparency
- Collaboration
- Adaptability
- Identity

Decision Systems



ICT Track & Trace: Perishables at Tesco

Health & Food – Shelf Life Monitoring



- 76 million foodborne illness
- 1.8 million deaths worldwide
- 325,000 hospitalizations in US
- 5000 deaths in US

- 91 million tons of food disposed to landfills in US
- 26% of US food supply
- 1 billion 'hungry' per year
- 40 million children losing sight

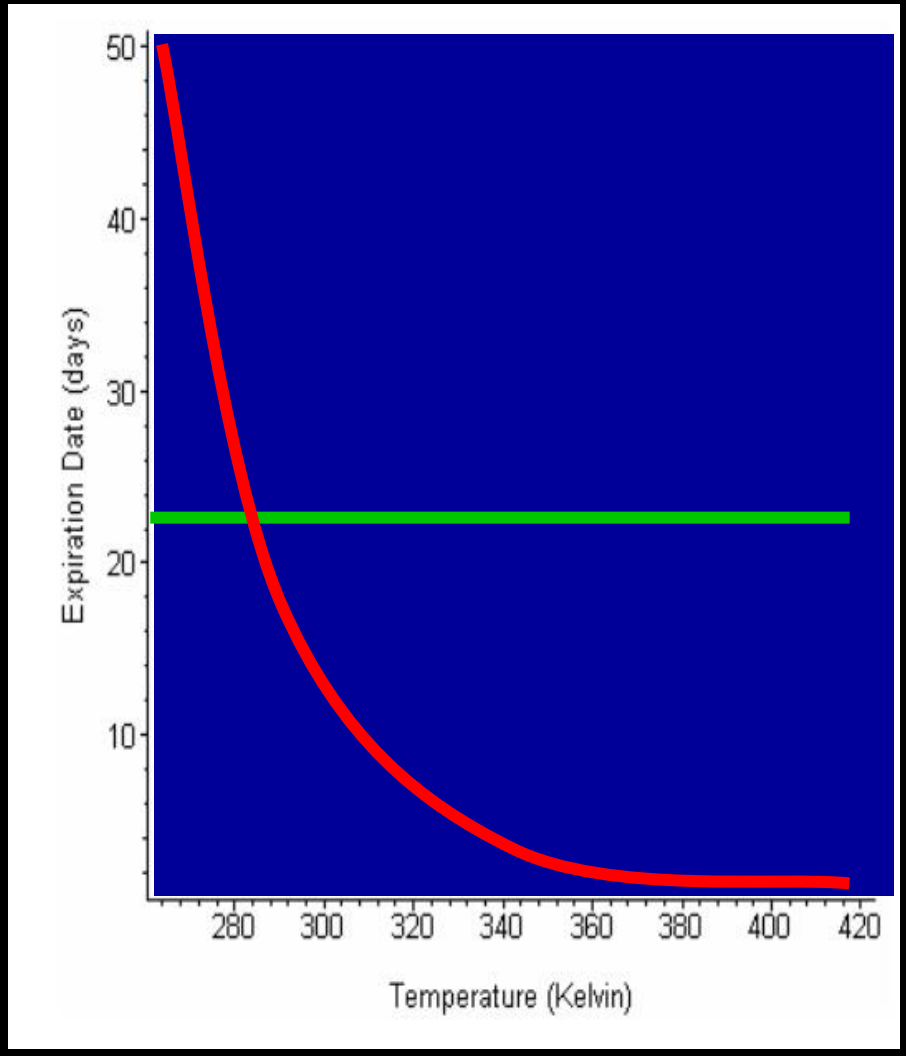
Shelf Life

$$\frac{\partial Q}{\partial t} = -k_1 e^{\left[-\frac{E_a}{R_g T(t)}\right]} Q^n$$

Variables

- E_a Activation energy
- k_1 Arrhenius constant
- n Order of the reaction
- T Temperature
- Q Quality
- t Time

Shelf Life


50
40
30
20
10
Expiration Date (days)
280
300
320
340
360
380
400
420
Temperature (Kelvin)

Shelf Life

Name: Activation Energy
Desc
Sym
Acce
ID: E
Clas
Type
Defa

Name: Arrhenius Constant
Descr
Symb
Acces
ID: EP
Class
Type:
Defau

Name: Temperature
Descr
Symb
Acces
ID: EP
Class
Type:
Defau

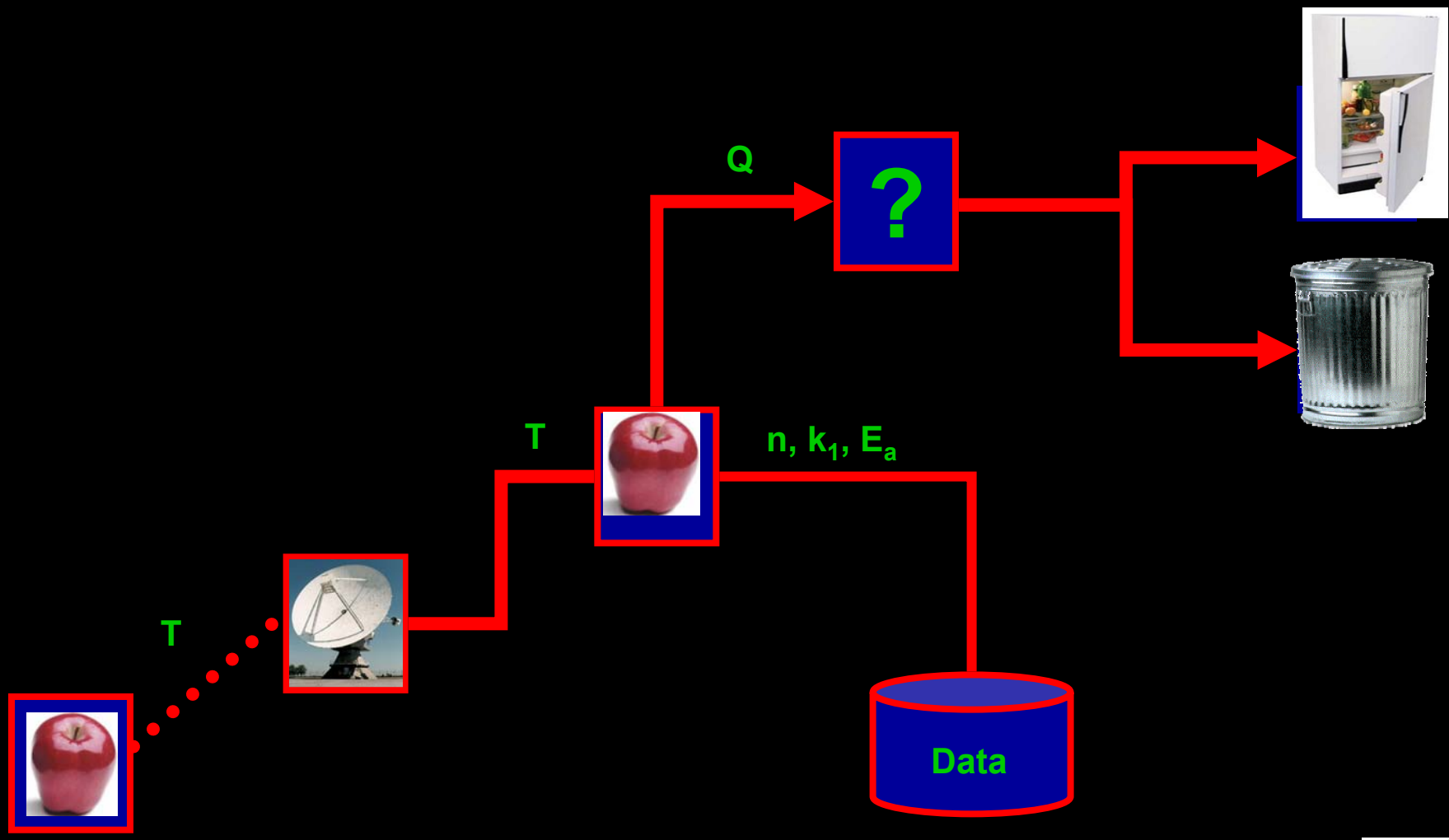
Name: Quality
Desc
Sym
Acce
ID: E
Clas
Type
Unit:
Defa

Name: Order of Reaction
Description: Order of Reaction
Symbol: *n*
Access: Read
ID: EPC: 01020084191000001289731
Class: Scalar
Type: Int
Unit:
Default: 1

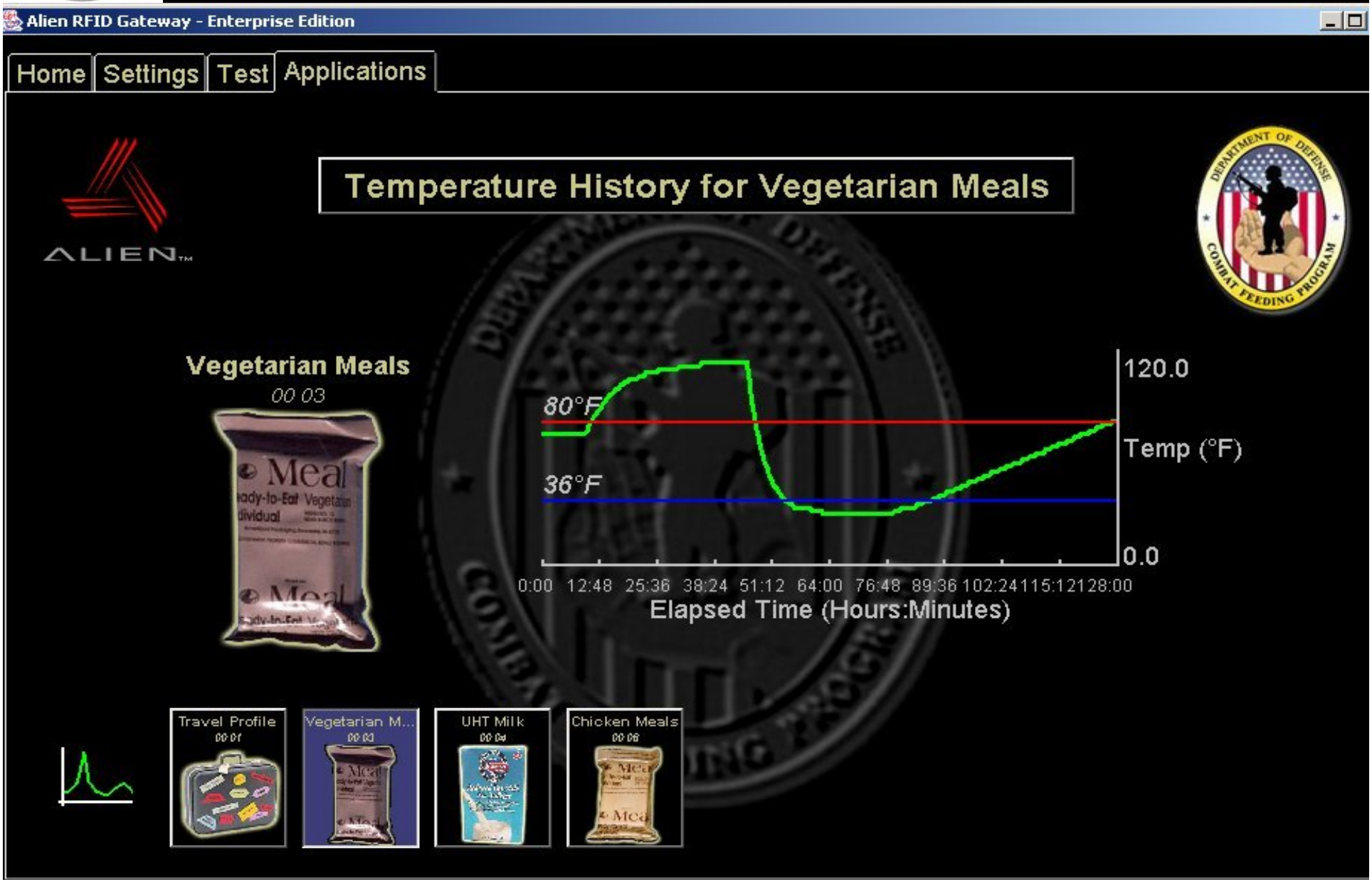
Food Quality

Name: Food Quality
Description: Food Quality based Arrhenius
Developer: Natick Army Laboratories
ID: EPC: 010300908808BF60000000AA
Comp: $0.25 per month
Type: Analytic
Rate: 1 to 10,000 sec
Algorithm:

Shelf Life >> Answers, not Numbers

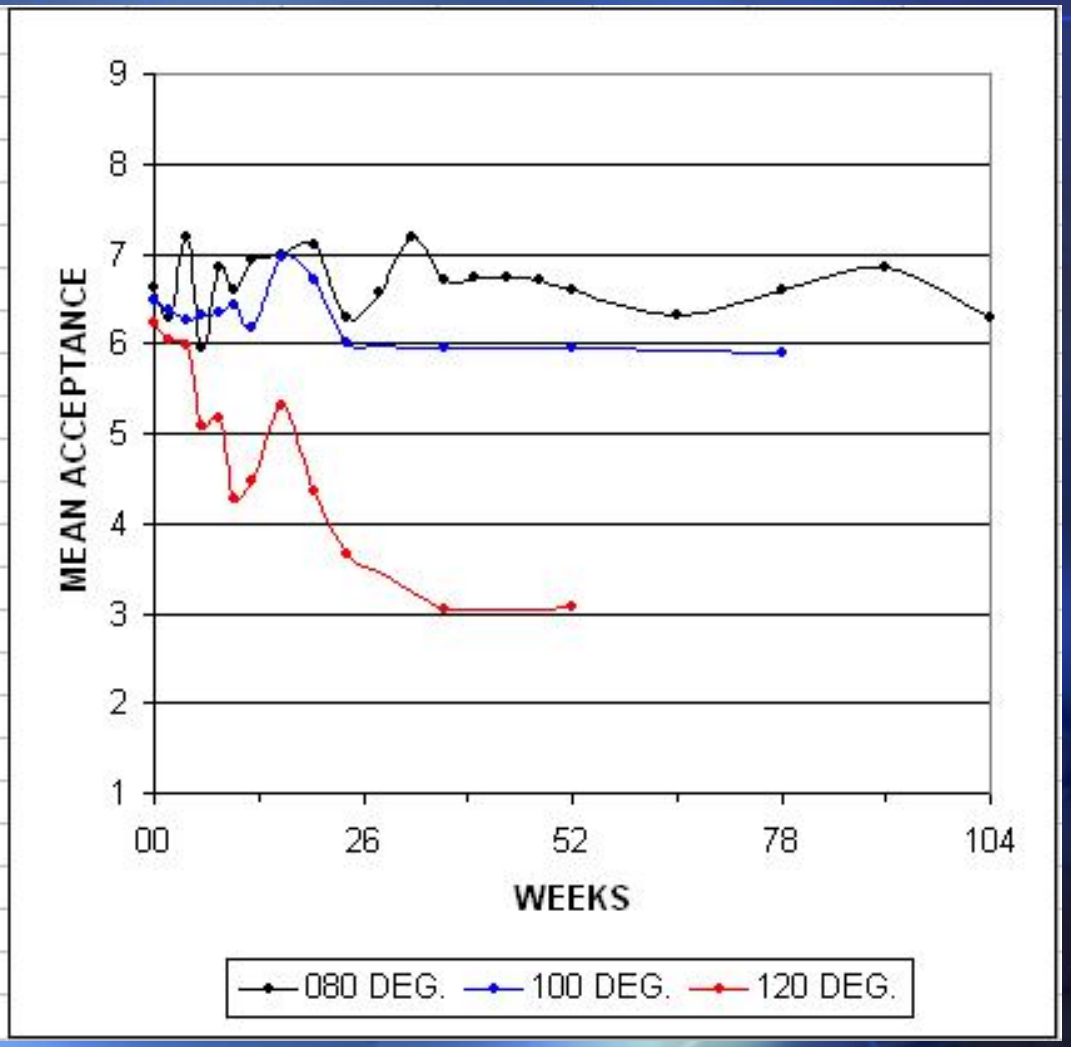


RFID Temperature Sensor in US DoD MRE Simulation

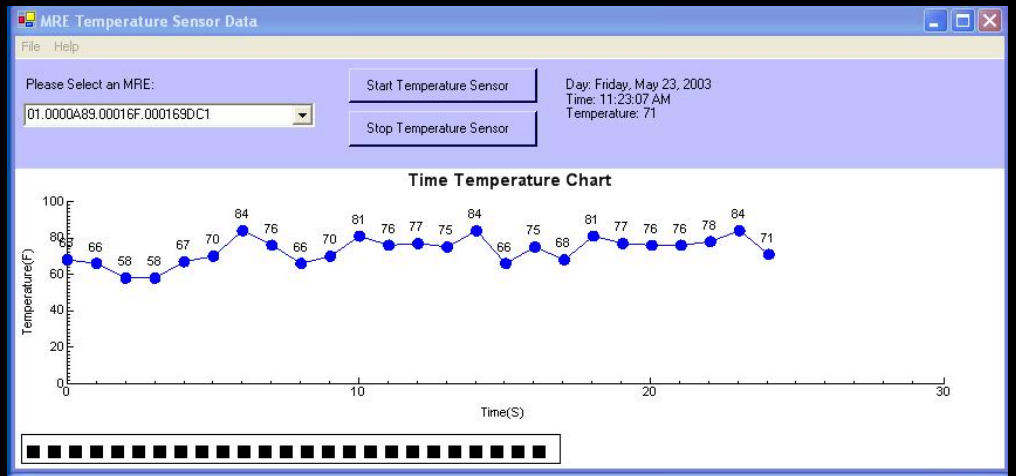


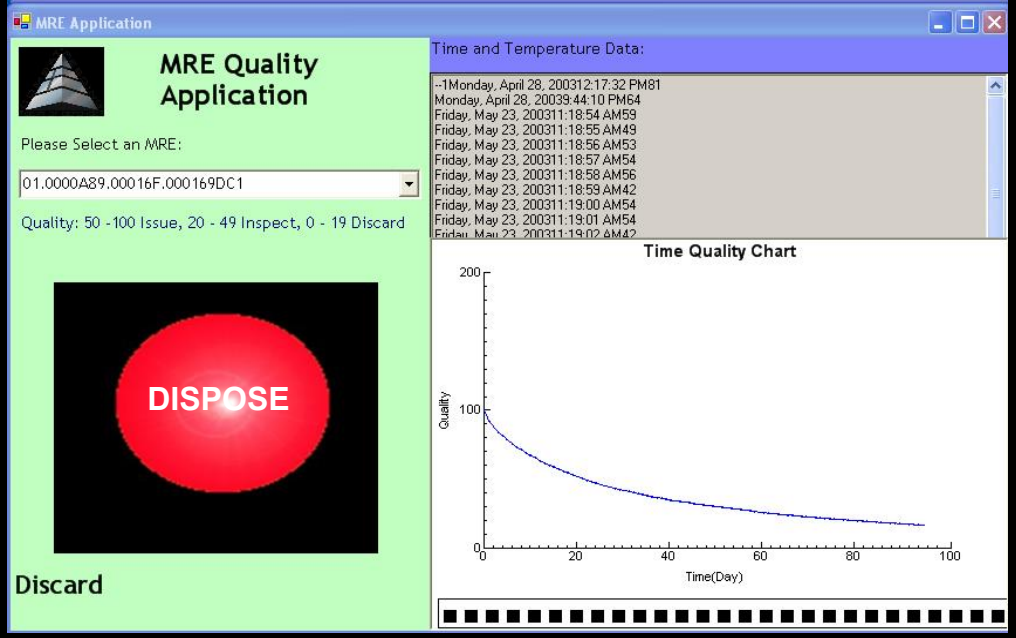
RFID Monitoring Perishables (MRE Simulation)

WKS	080 DEG.	100 DEG.	120 DEG.
00	6.622	6.486	6.243
02	6.282	6.359	6.026
04	7.194	6.250	5.972
06	5.949	6.308	5.077
08	6.850	6.350	5.175
10	6.600	6.429	4.286
12	6.944	6.167	4.472
16	7.000	6.947	5.316
20	7.111	6.694	4.361
24	6.300	6.000	3.667
28	6.579		
32	7.189		
36	6.694	5.944	3.028
40	6.730		
44	6.730		
48	6.703		
52	6.583	5.944	3.056
65	6.316		
78	6.583	5.889	
91	6.842		
104	6.300		
130			
156			



RFID Monitoring Expiration Date (MRE Simulation)





Dr Shoumen Palit Austin Datta < shoumen@mit.edu > MIT Forum for Supply Chain Innovation & MIT School of Engineering

RFID is not a panacea: it is a data acquisition tool

Manual Identification >> Barcode

Then

TAYTOS

Repository

Automatic Identification >> RFID

Paradigm Shift ?

01 0203D2A 916E8B 0719BAE03C

Now

TAYTOS

Repository

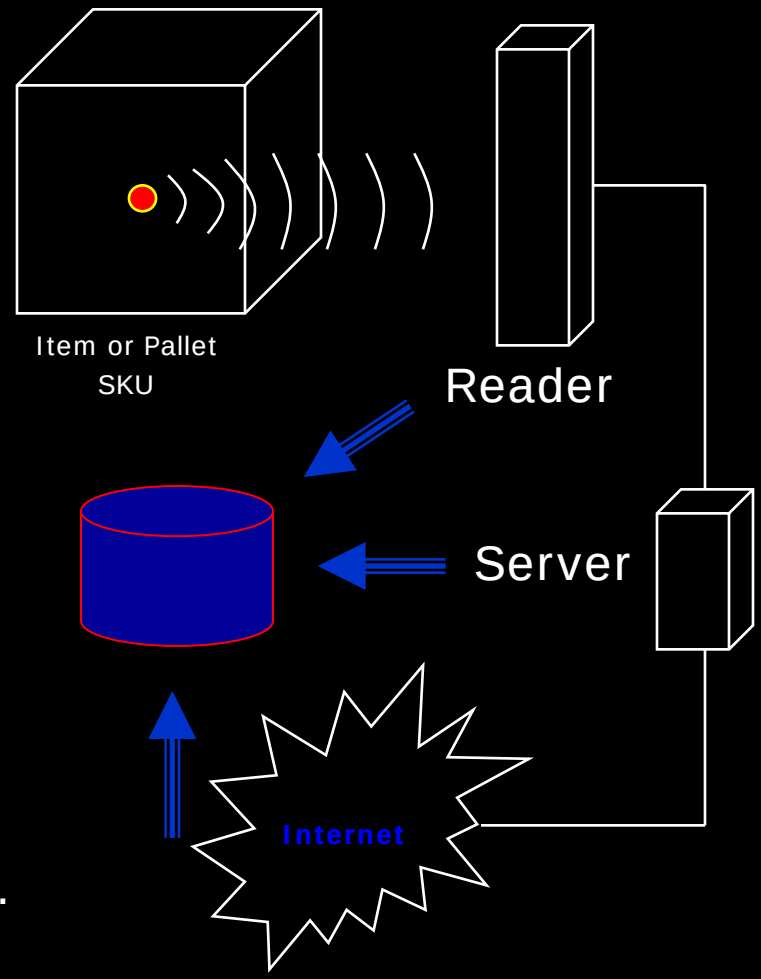
Dynamic Systems Adaptability ?

Radio Frequency Identification

- Radio Frequency Identification
- **Electronic Product Code (EPC)**

- RF waves transfer data (object to reader)
- Re-writable secure data
- Identify individual items
- Line of sight not required
- Stable in variety of conditions
- Read through most non-metals
- RFID transponders 5 cents ? ($0.25 - $150)
- RFID readers: $2000 to $10 (SDR?)
- Infrastructure: Profit over Physics?
- RFID Interface (Real-time data) to ERP (?)
- Can RDBMS handle data flow? Streaming DB.
- Auto ID standard Global EPC at UCC.EAN
- Limited spatial capacity of 1 kbpsm^2

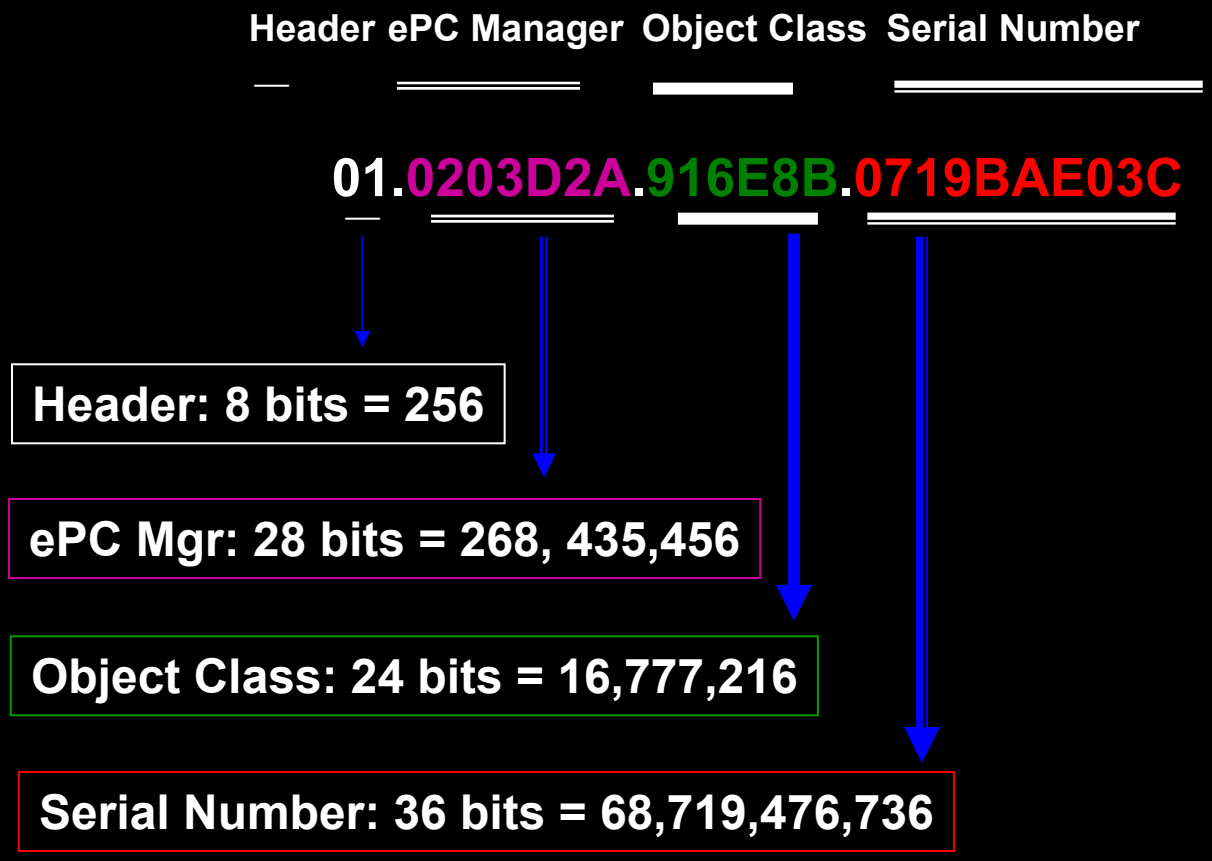
- **RFID Tag (Active UWB)**

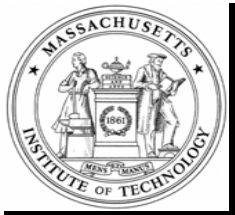


Data Acquisition: Beyond Barcode

Electronic Product Code (EPC) 96 bits

268 million companies can each categorize 16 million different products and each product category may contain over 68 billion individual items

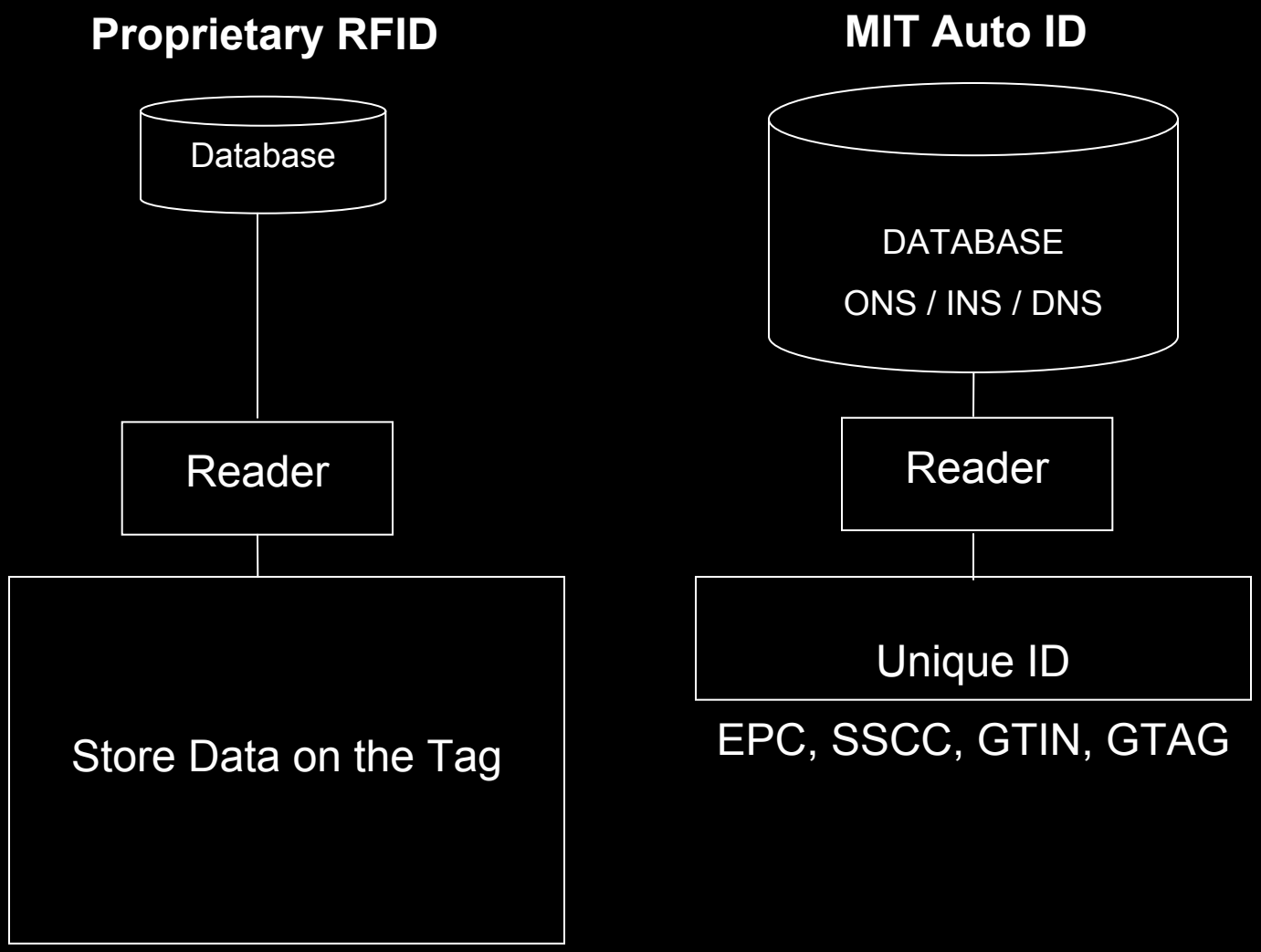




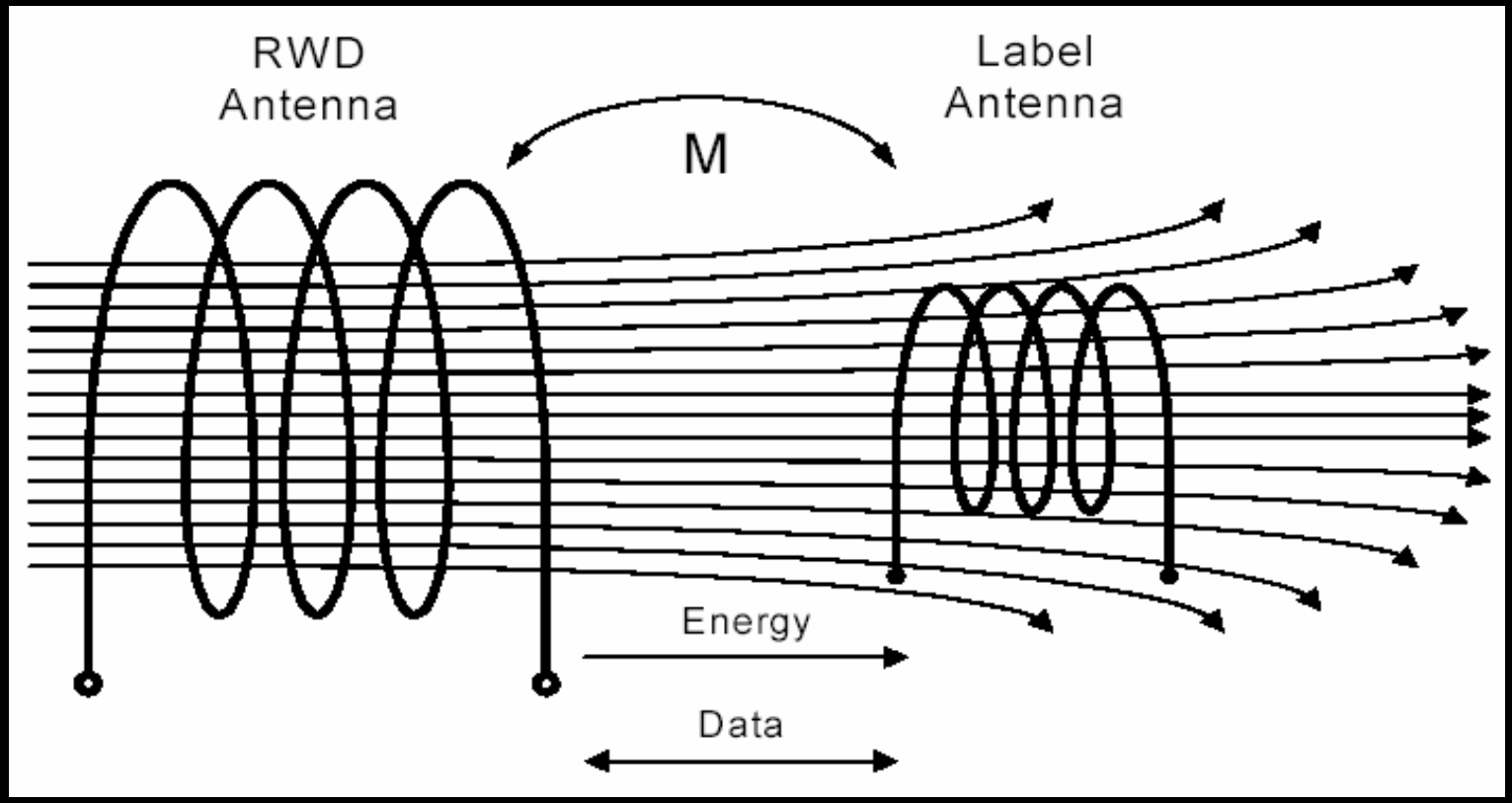
Shannon to Boston

151.193.204.72

Internet-Catalysed Evolution: Relevant RFID Data

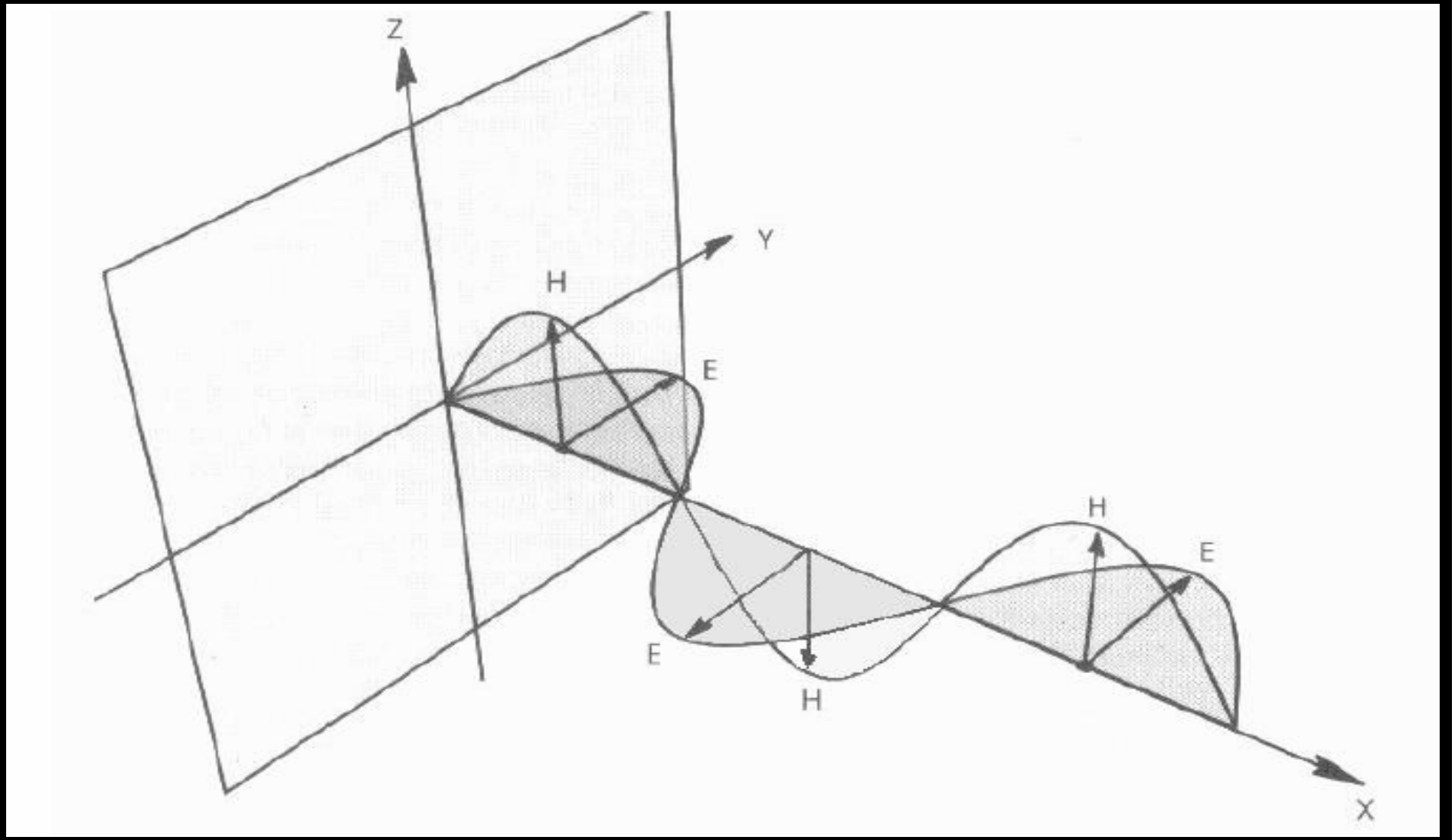


Inductive Passive 13.56 MHz and <135 KHz



Near Field
ASK, PSK

Electromagnetic Field Ultra High Frequency RFID



Country Specific Power Agnostic ?

Global Power Regulation in RFID Technology Impacts Business Processes

UHF (400-1000 MHz)

Band	Region	Max. Power EIRP
433.05-434.79 MHz	Europe	25mW
865-868 MHz	Europe	4 Watts FHSS (proposed by ETSI for Europe
868-870 MHz	Europe	500mW* Still under consideration
870-875.4 MHz	Europe	4 Watts FHSS (proposed by ETSI for Europe
902-928Mhz	USA/Canada	50mV/m at 3 meters (Single freq. Systems)
	USA/Canada	4W using spread spectrum
	USA/Canada	30W FCC Part 90, LMS (3W conducted)
918-926MHz	Australia	1W all new equipment designs
915.3-915.6 MHz	South Africa	15W (5 Watt conducted)
915-921 MHz	Europe	4 Watts FHSS (proposed by ETSI for Europe

Microwave

2.4-2.4835 GHz	Europe	25 mW
	Europe	500mW spread spectrum
	USA/Canada	50mV/m at 3 meters (Single freq. Systems)

Where	Approved EIRP* Radiated Power from Reader	Distance
EU	0.5 Watt	0.7 metres
US & Canada	4.0 Watt	2.0 metres
US site license	30 Watt	5.5 metres

Data: AIM

Radiated Power ≈ Energy Field » Read Range

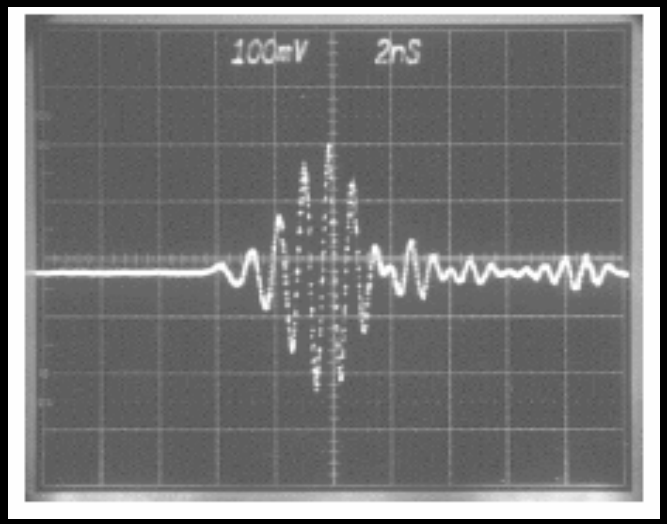
**** EIRP -*** effective isotropic radiated power

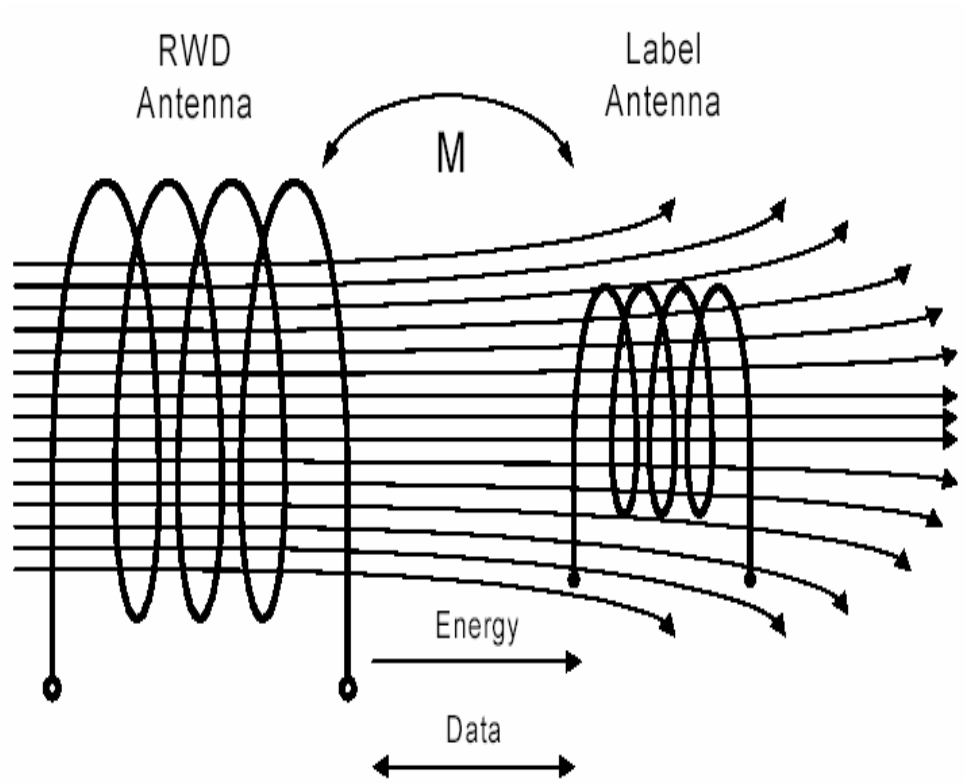
Why fixed frequency RFID is of limited use!

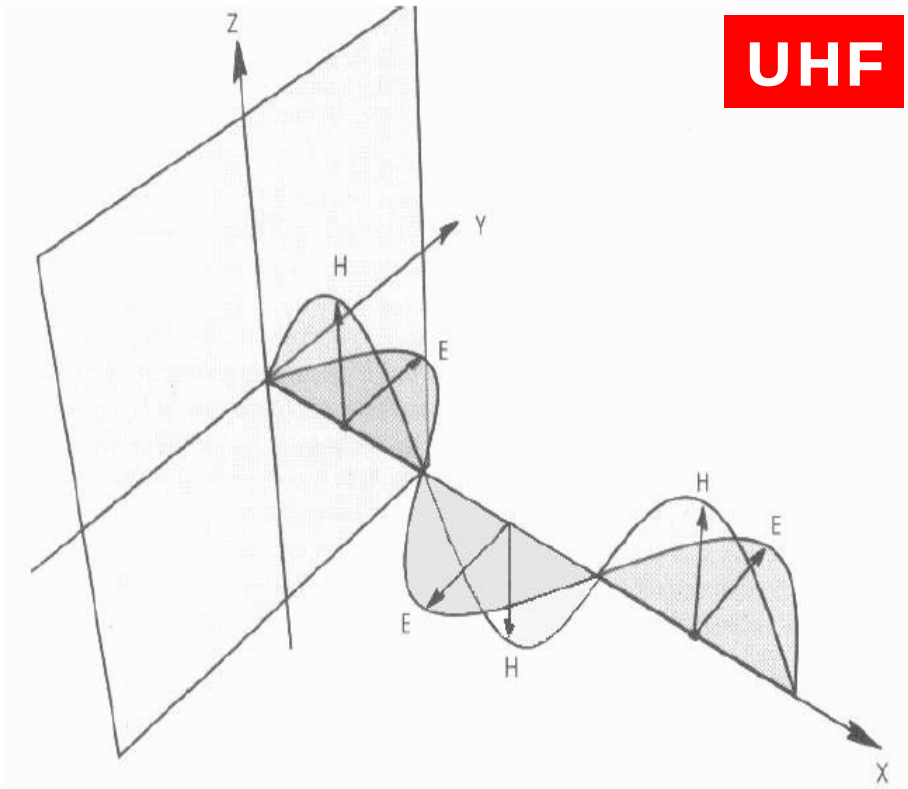
One RF Solution: Ultrawideband

UWB – Pulse Transmission

Marconi's (1894) "Spark-Gap"

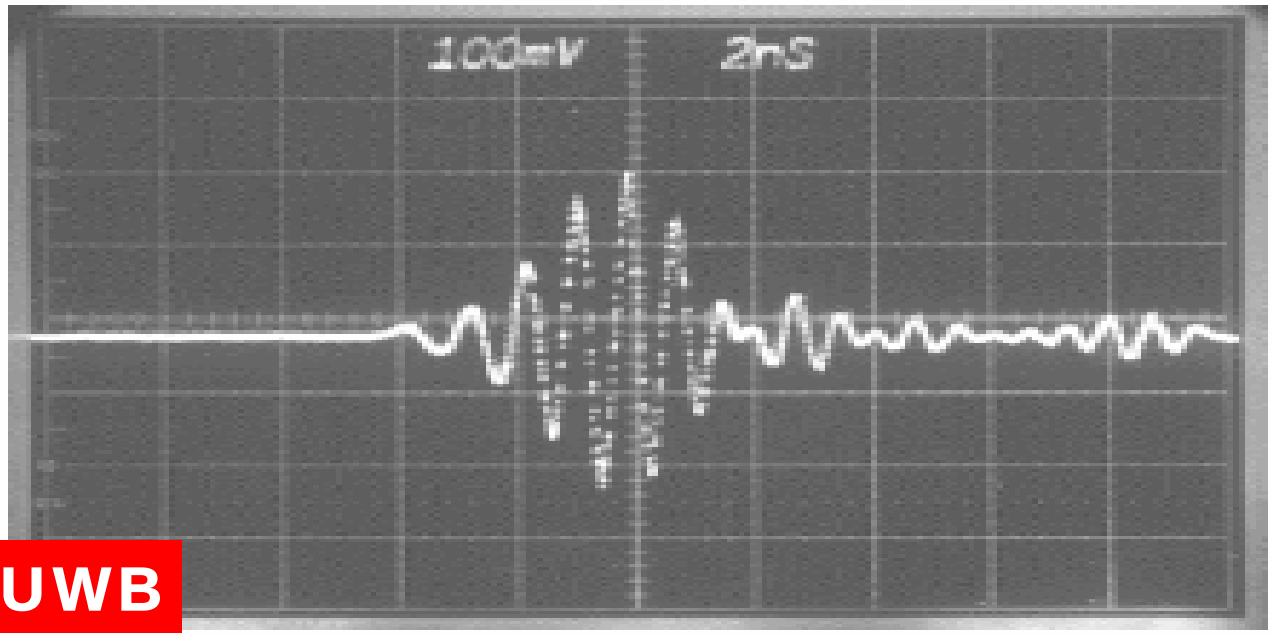






UHF

Passive 13.56 MHz



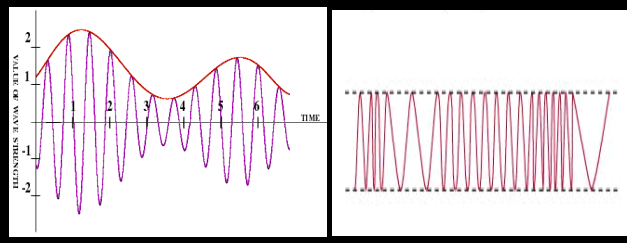
UWB – Pulse Transmission
Marconi's (1894) "Spark-Gap"

UWB

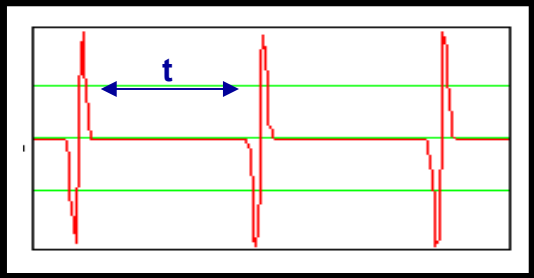
Why UWB: Geography Agnostic

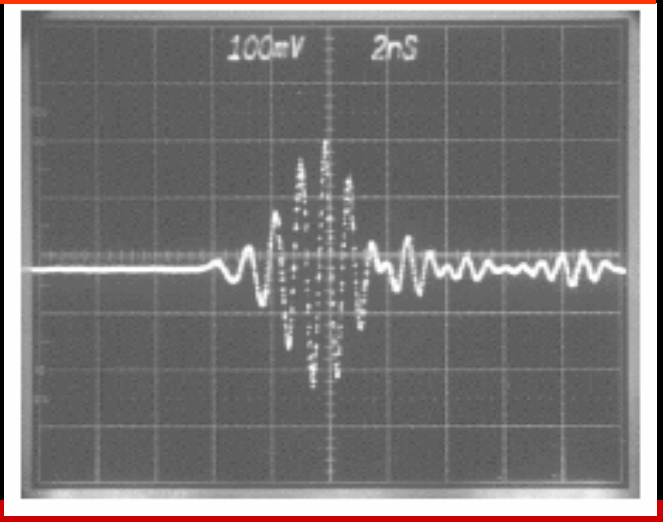
Longer Range from Less Power

Continuous wave RF modulates data signals over carrier waves.

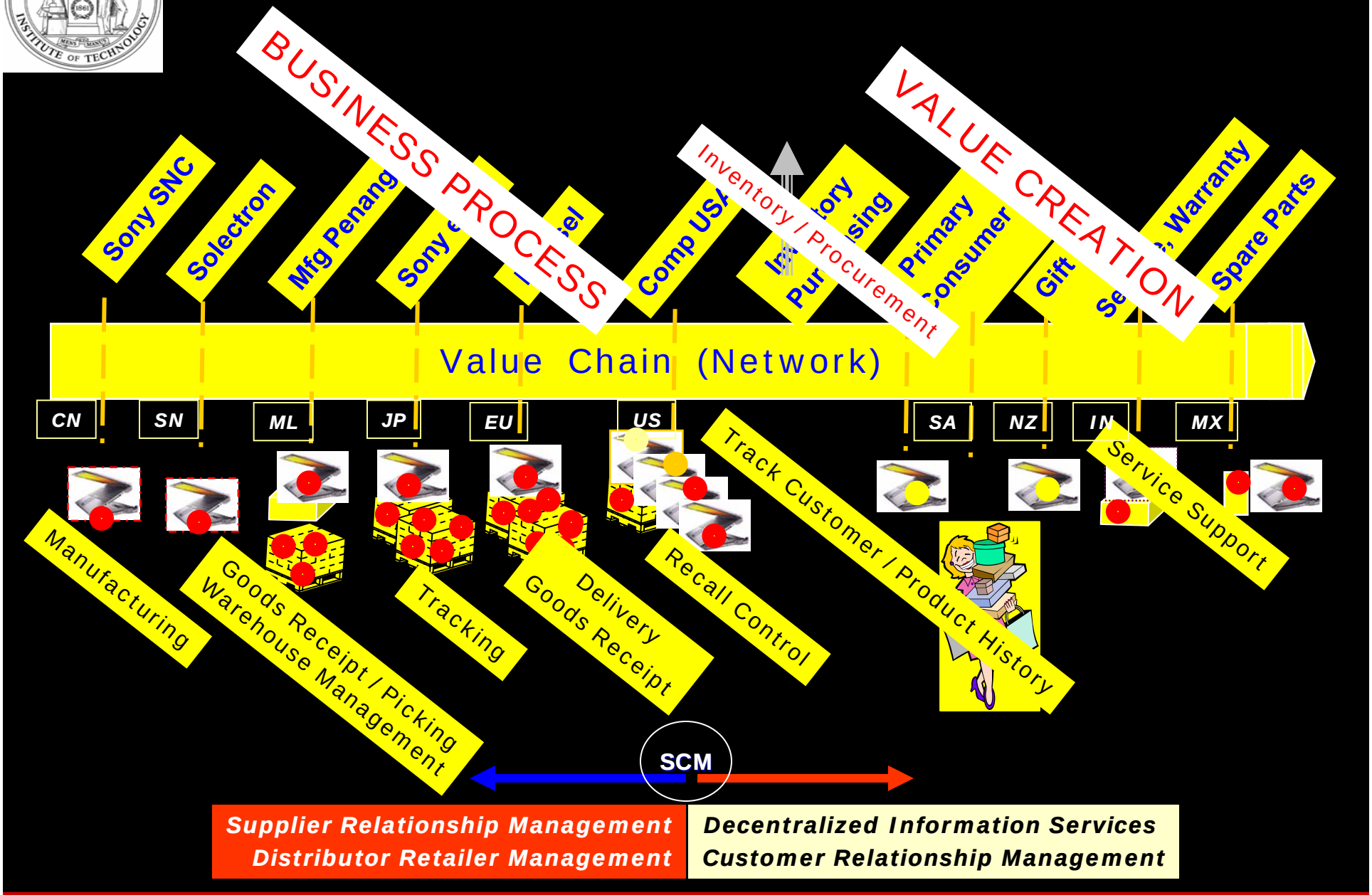


- UWB encodes information as pulse of RF energy
- Timing of pulses is used to relay information

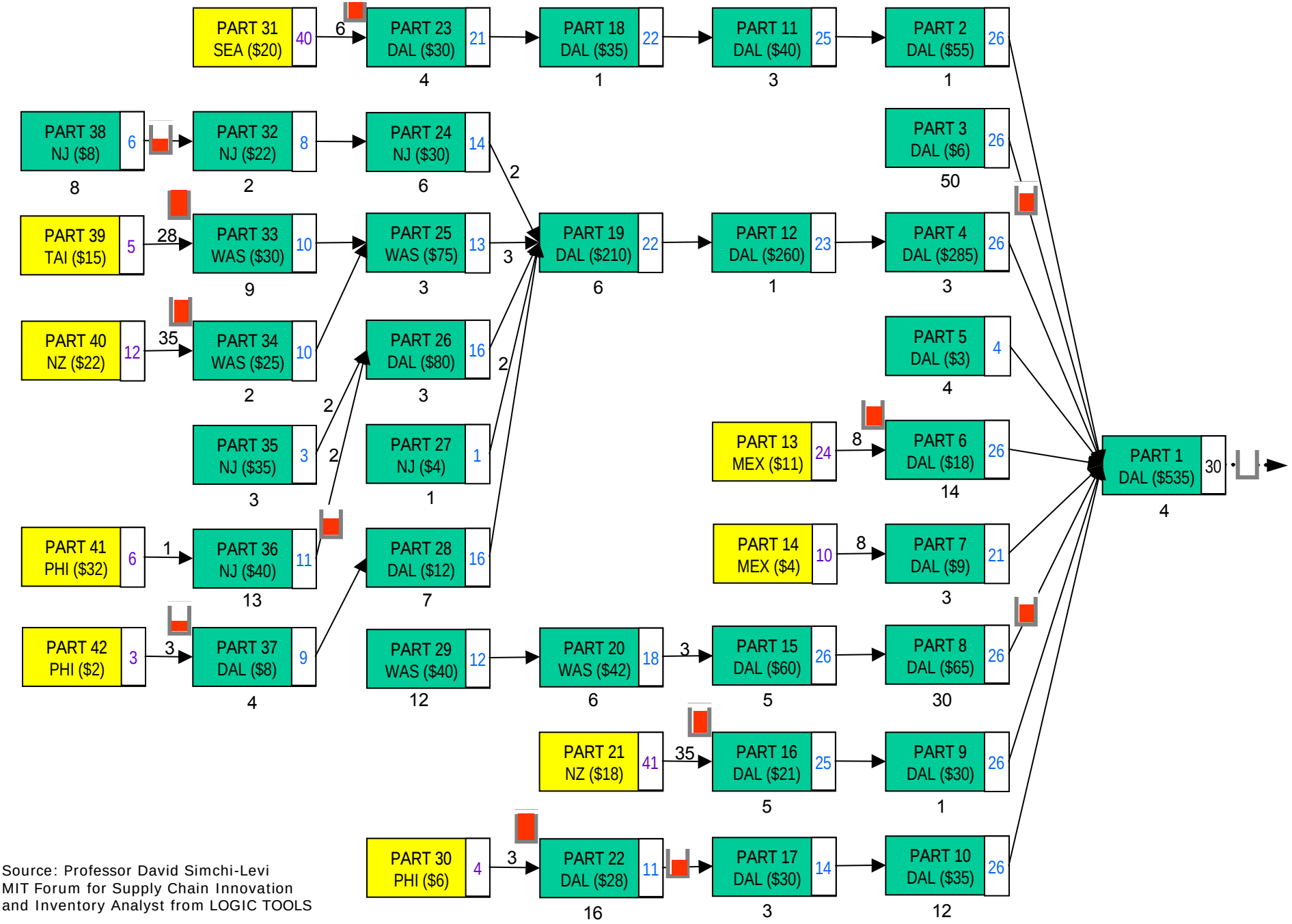




Instant ROI from RFID: Low Hanging Fruit ?

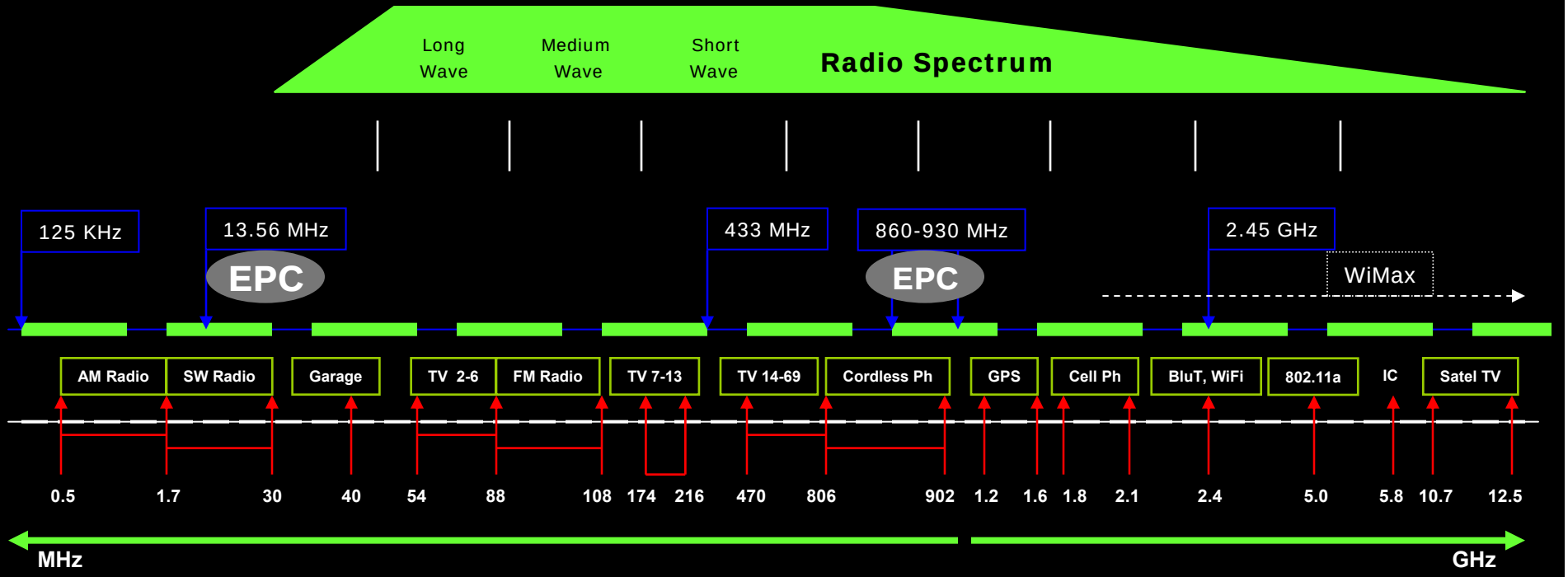


RFID: Inventory Optimization and Product Lifecycle



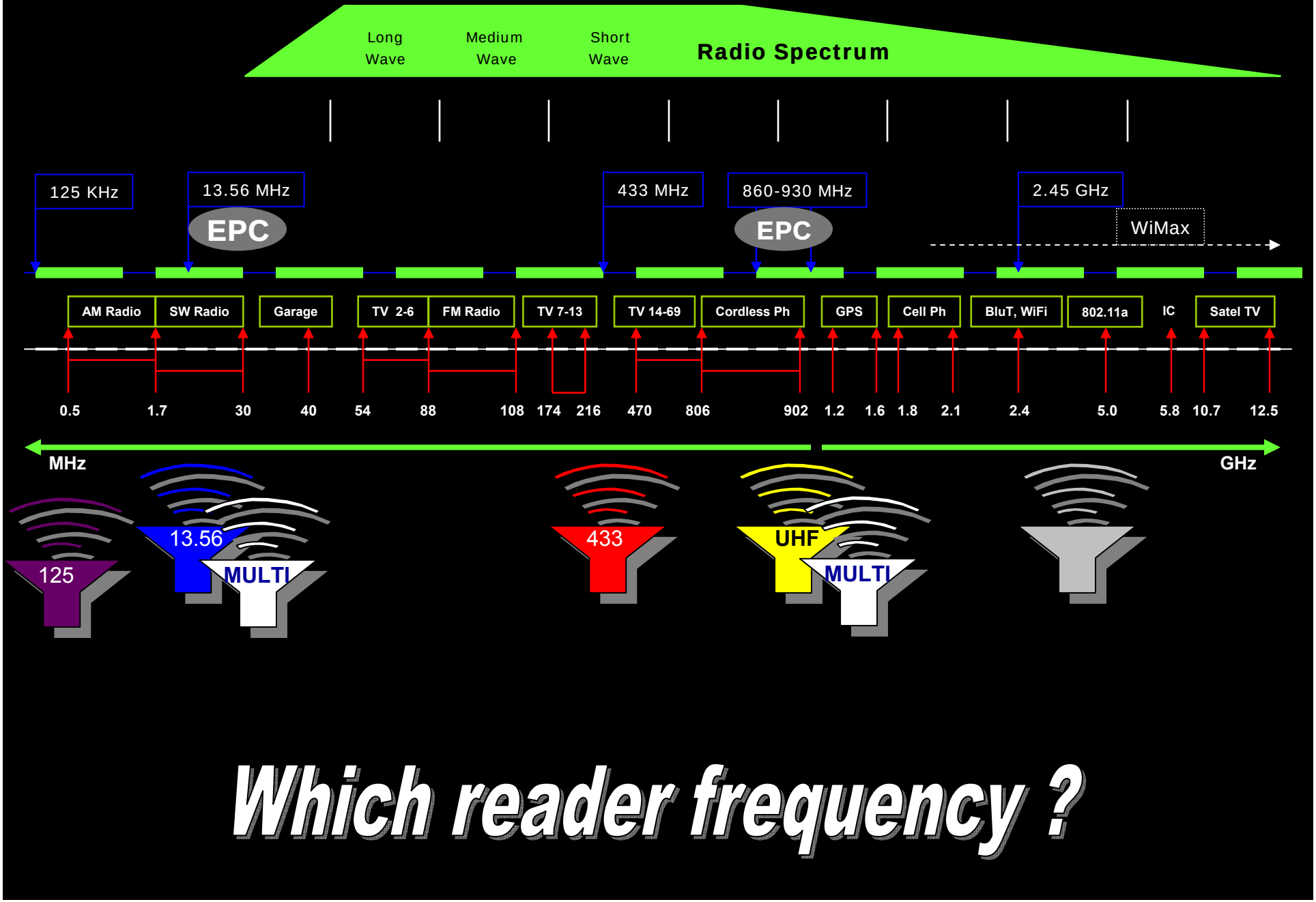
Source: Professor David Simchi-Levi
MIT Forum for Supply Chain Innovation
and Inventory Analyst from LOGIC TOOLS

EPC Heterogeneity



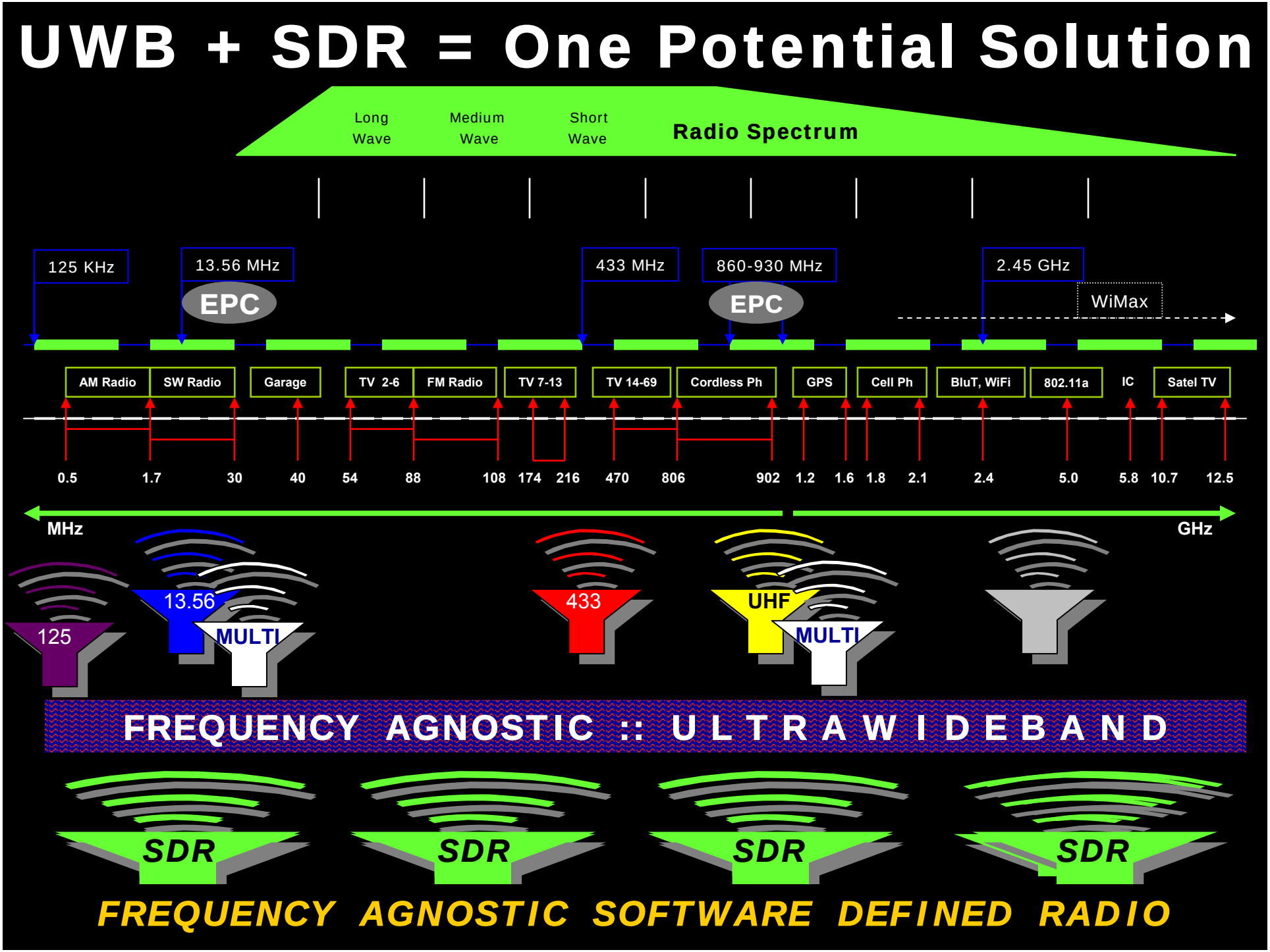
Which RFID frequency ?

RFID-EPC Tag+Reader Heterogeneity



Which reader frequency ?

UWB + SDR = One Potential Solution



Partial Source: Shrouds of Time – The History of RFID

Modified from: Han Pang Huang, National Taiwan University

RFID > Radio Frequency Identification

1940

RFID born out of Radar effort (WWII)

1948
Harry Stockman invents RFID. Publishes paper, "Communication by Means of Reflected Power"

1950

RFID crawls out

1950
D.B. Harris patents RFID. "Radio transmission systems with modulatable passive responder"

1952
F.L. Vernon "Application of the microwave homodyne"

1959
Identification of Friend or Foe (IFF) long-range transponder system reaches breadboard demonstration stage.

1960

Theory of RFID, field trials planned

1963-1964
R.F. Harrington advances theory with "Field measurements using active scatterers" and "Theory of loaded scatterers"

1966
Commercialization of EAS, 1-bit Electronic Article Surveillance

1970

Early adopters implement RFID

1973

1977
RCA develops "Electronic identification system"

1975
Los Alamos National Lab (LANL) releases RFID research to public sector, publishes "Short-range radio-telemetery for electronic identification using modulated backscatter"

1976-1977
LANL RFID spin-offs Indentronix and Amtech

1975-1978
Raytheon, Fairchild & RCA develop RFID

1980

Commercial RFID endeavors sprout

1982
Mikron founded; bought by Philips

1987
First RFID road toll collection implemented in Norway

1990

Many RFID standards emerge

1991
TI creates TIRIS to develop and market RFID

1992-1995
Multi-protocol traffic control and toll collection implemented in Texas, Oklahoma, and Georgia (USA)

1998
David Brock and Sanjay Sarma of MIT publishes an idea: 'Internet of Things'

1999
Auto ID Center created at MIT. Retailers drive to standardize EPC

2000

RFID hype, peaks

2003
UPC and EAN forced by US retailers to promote EPC

2005
Wal-Mart and US DoD fuels the hype curve by demanding suppliers use passive RFID and EPC.

Vast number of RFID companies and 'short-sight' enters the market.

Dr Shoumen Palit Austin Datta < shoumen@mit.edu > MIT Forum for Supply Chain Innovation & MIT

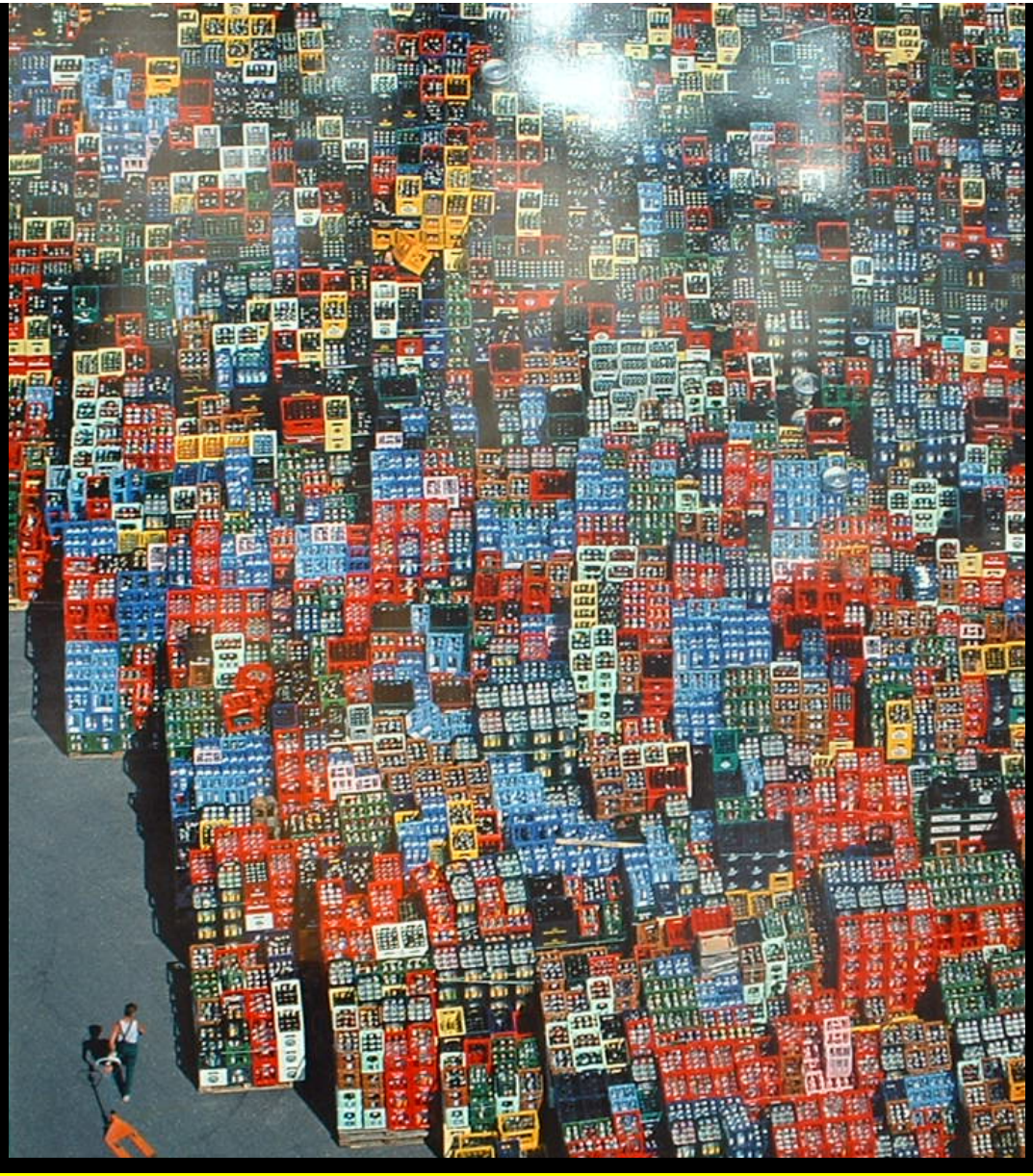
Paul A. David and Gavin Wright in *The Economic Future in Historical Perspective (Oxford University Press, 2003)*

The Economic Future in Historical Perspective

Statistically documented discontinuity can be traced to critical engineering and organizational advances connected with the electrification of industry. These developments marked the culminating phase in the diffusion of the **"dynamo" as a general purpose technology** that enabled significant fixed-capital savings, while simultaneously increasing labor productivity. A narrow technological explanation of the post-WWI industrial productivity surge proves to be inadequate. It neglects the concurrence of those developments with important structural changes in US labor markets and fails to do justice to the **significance of complementarities** that emerged between **managerial and organizational innovations** and the dynamo-based factory technology, on the one hand, and, on the other, between both forms of innovation and macroeconomic conditions of 1920's.

The Economic Future in Historical Perspective

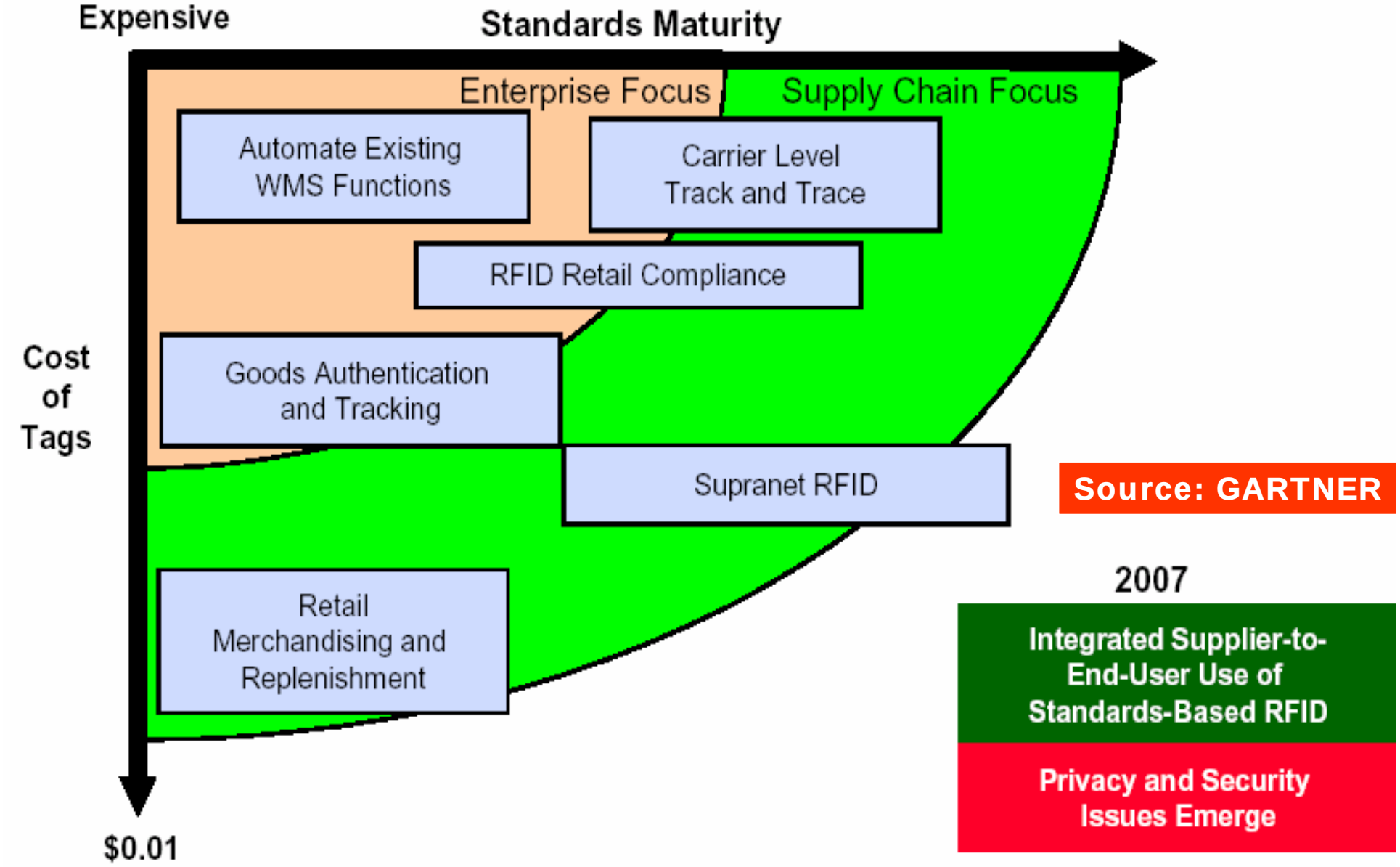
Slow pace of adoption prior to the 1920's was attributable largely to the lack of profitability of replacing still serviceable manufacturing plants adapted to the old regime of mechanical power derived from water and steam. Coexistence of older and newer forms of capital often restricted the scope for exploiting electricity's potential. Prior to 1920, the group drive system of within-plant power transmission remained in vogue. With this system (in which electric motors turned separate shafting sections, so that each motor drove related groups of machines) **primary electric motors often were merely added to the existing stock of equipment.** With the favorable investment climate of the 1920's, firms had the opportunity to switch from group drive to unit drive transmission, where individual electric motors were used to run machines and tools. Advantages of the unit drive extended well beyond savings in fuel and in energy efficiency. They also made possible single-story, linear factory layouts with reconfigured machine placement permitting flow of materials through the plant that was both more rapid and more reliable. Rearrangement of the factory contributed to cost savings in materials handling operations.



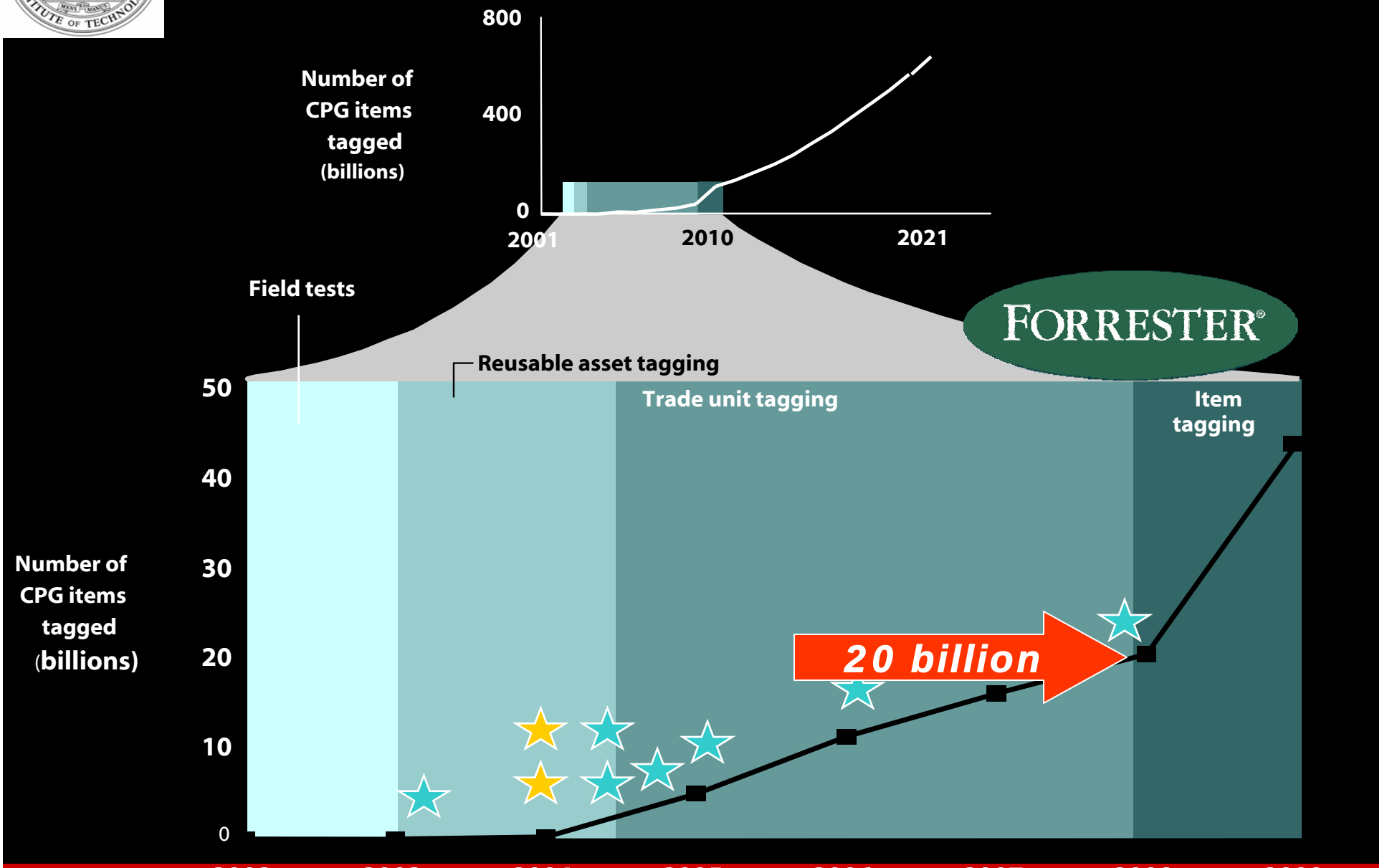
Slap on a RFID tag and harvest ROI

Beverage and Beer Crates in Lower Saxony (Germany)

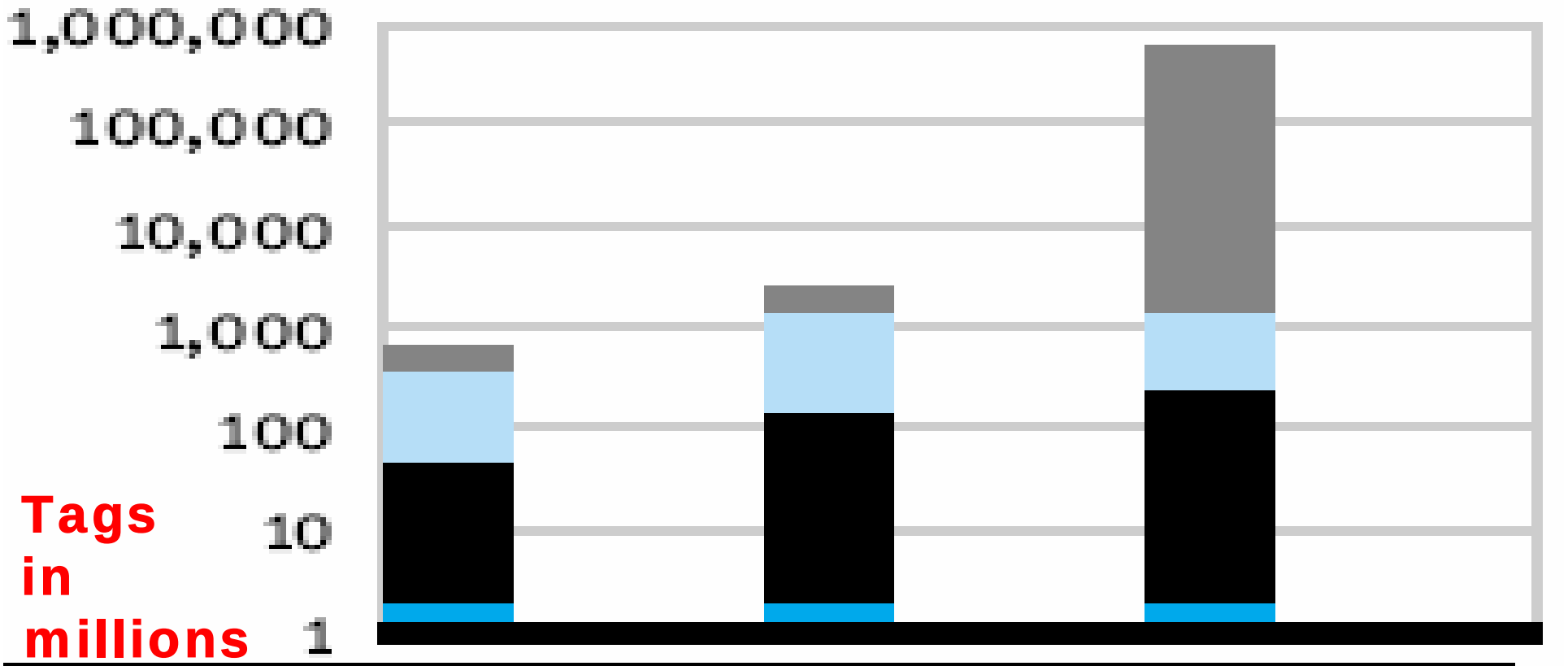
HYPE > Smart Objects in Real-time Adaptive Supply Network



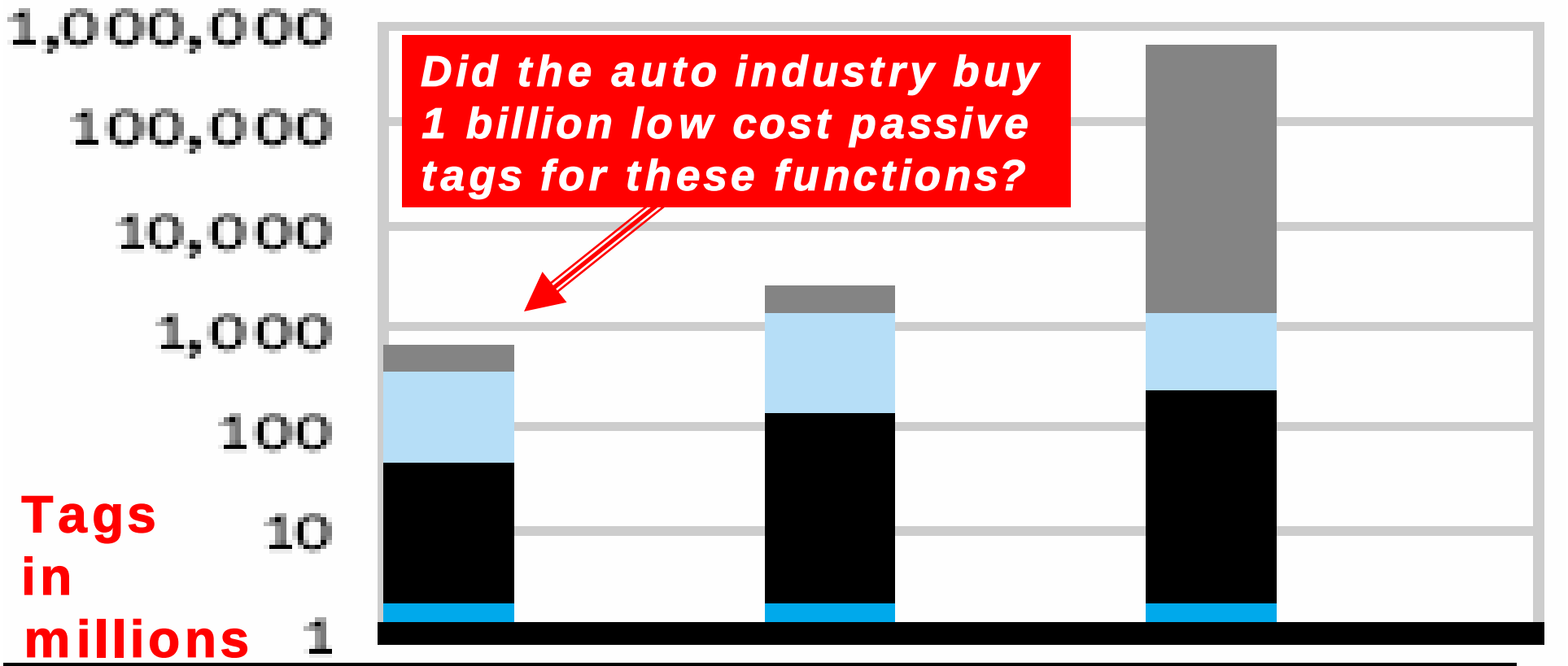
RFID tagged objects in CPG < Hype



2003 Proposal from Auto ID Center (Switzerland)



Sokymat, market leader in transponder sales, sold 30 million RFID transponders (50%) to the automotive industry in 2003



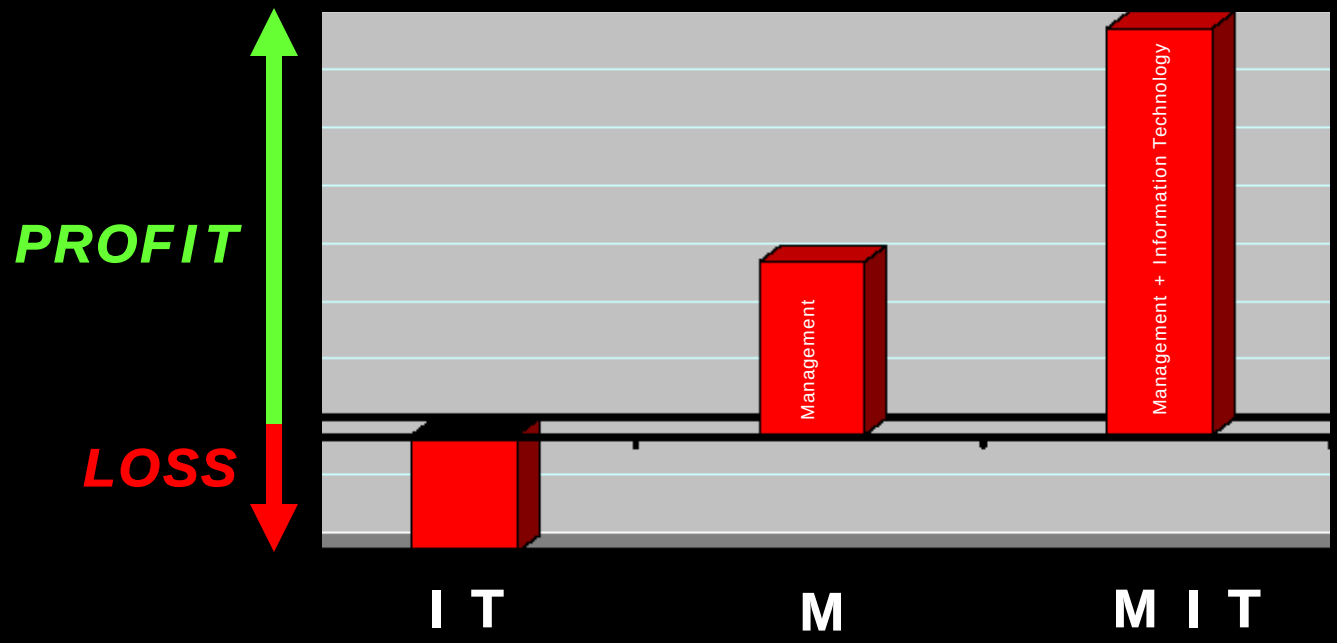
Standards: Too many to choose from?

EPC standard may not be used in manufacturing applications.

Larry Graham
Auto Id Chief
General Motors
May 9 2005

AIAG B-11 tire tracking standard now includes fields to enable EPC. AIAG added a data identifier that would indicate when EPC data was encoded in a UHF RFID tag.

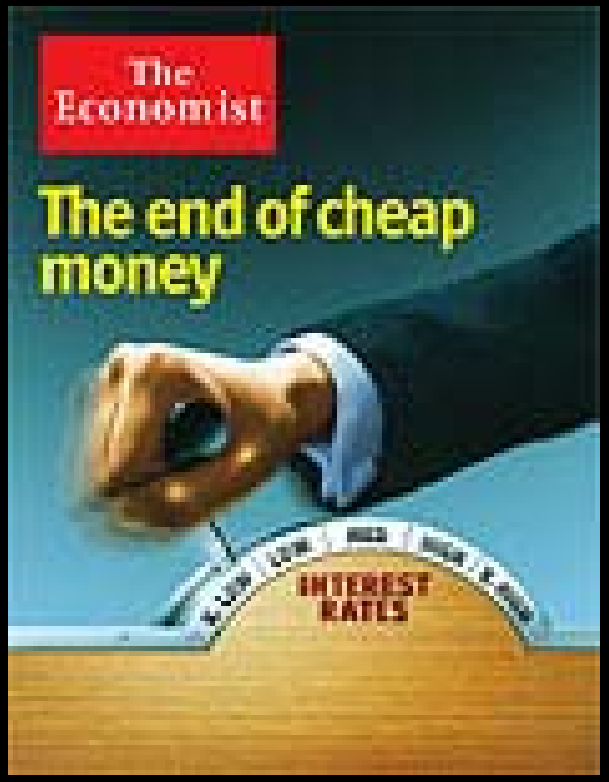
Solution: Technology ? RFID ? EPC ?



If you look at RFID's history, you'll see tremendous amount of promise and little achievement. The technology is process immature. We are still very much in the over-hyped phase.

Dr Daniel Engels, Research Director, MIT Auto-ID Lab (2005)

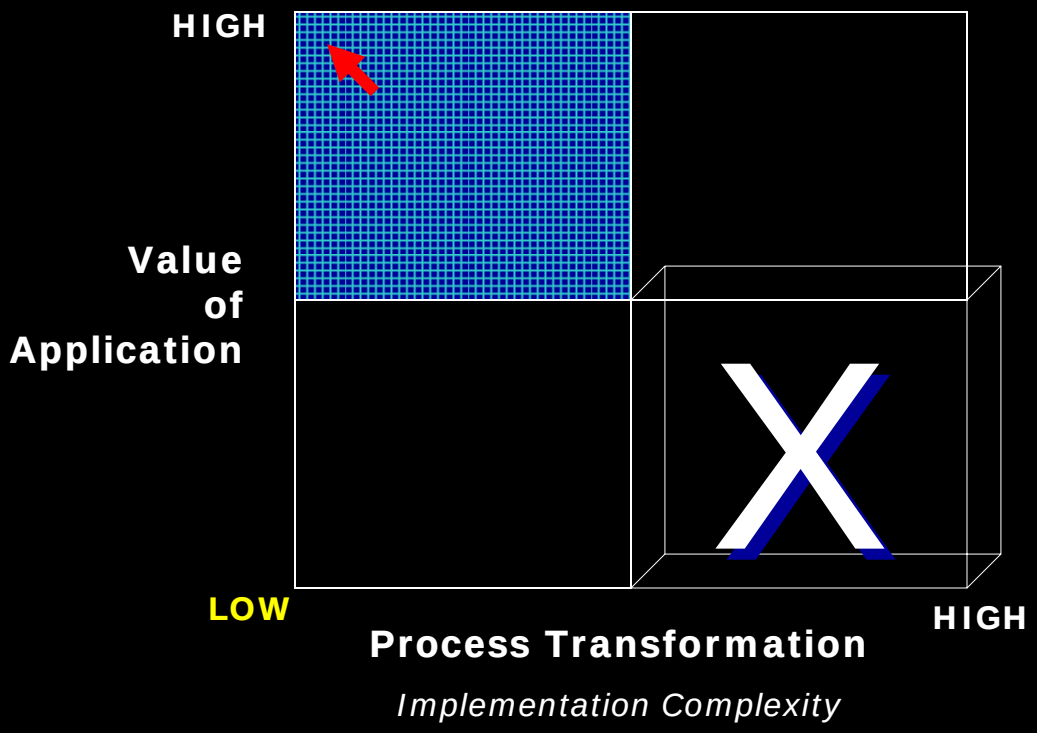
“Likewise, in the past few decades most of the companies that have created truly extraordinary amounts of wealth have done so by inventing great processes, not great products (technology). Dell, Toyota and Wal*Mart, for example, have risen to the top of their respective industries by coming up with amazingly efficient ways of getting quite ordinary products into the hands of consumers more cheaply than their rivals.”



Source:

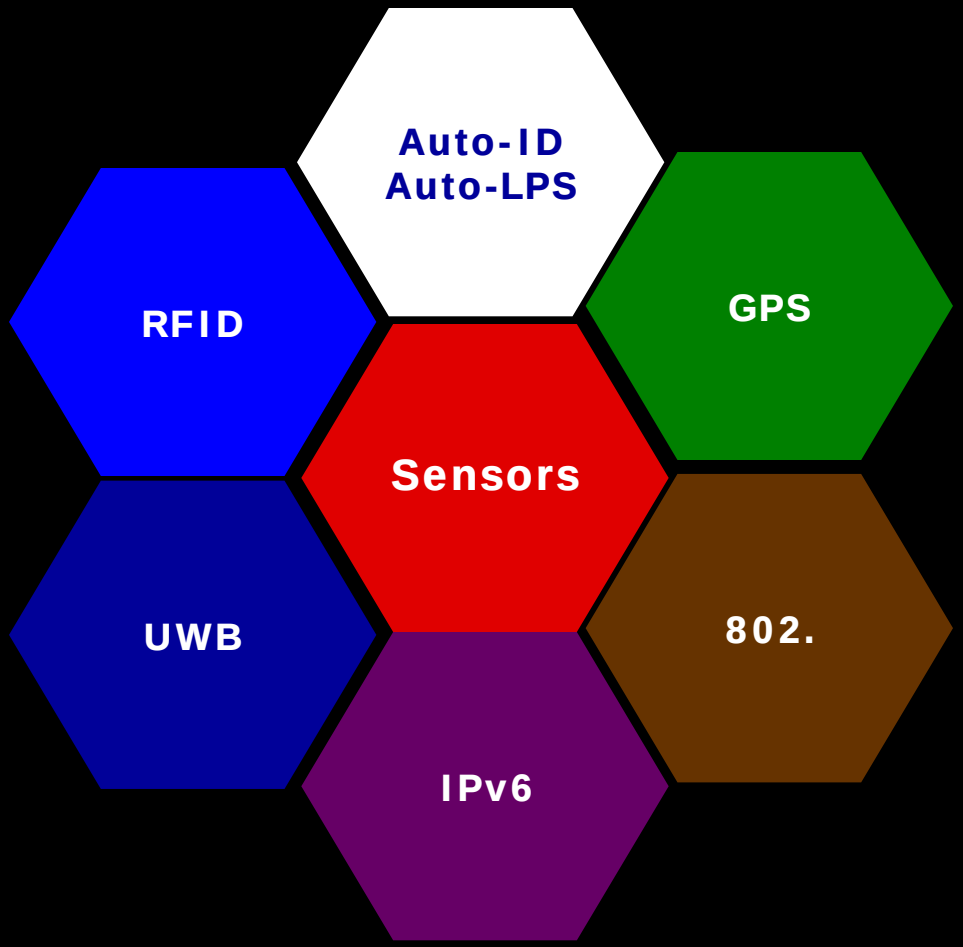
The Economist, April 24th, 2004

Are you asking the right questions ?

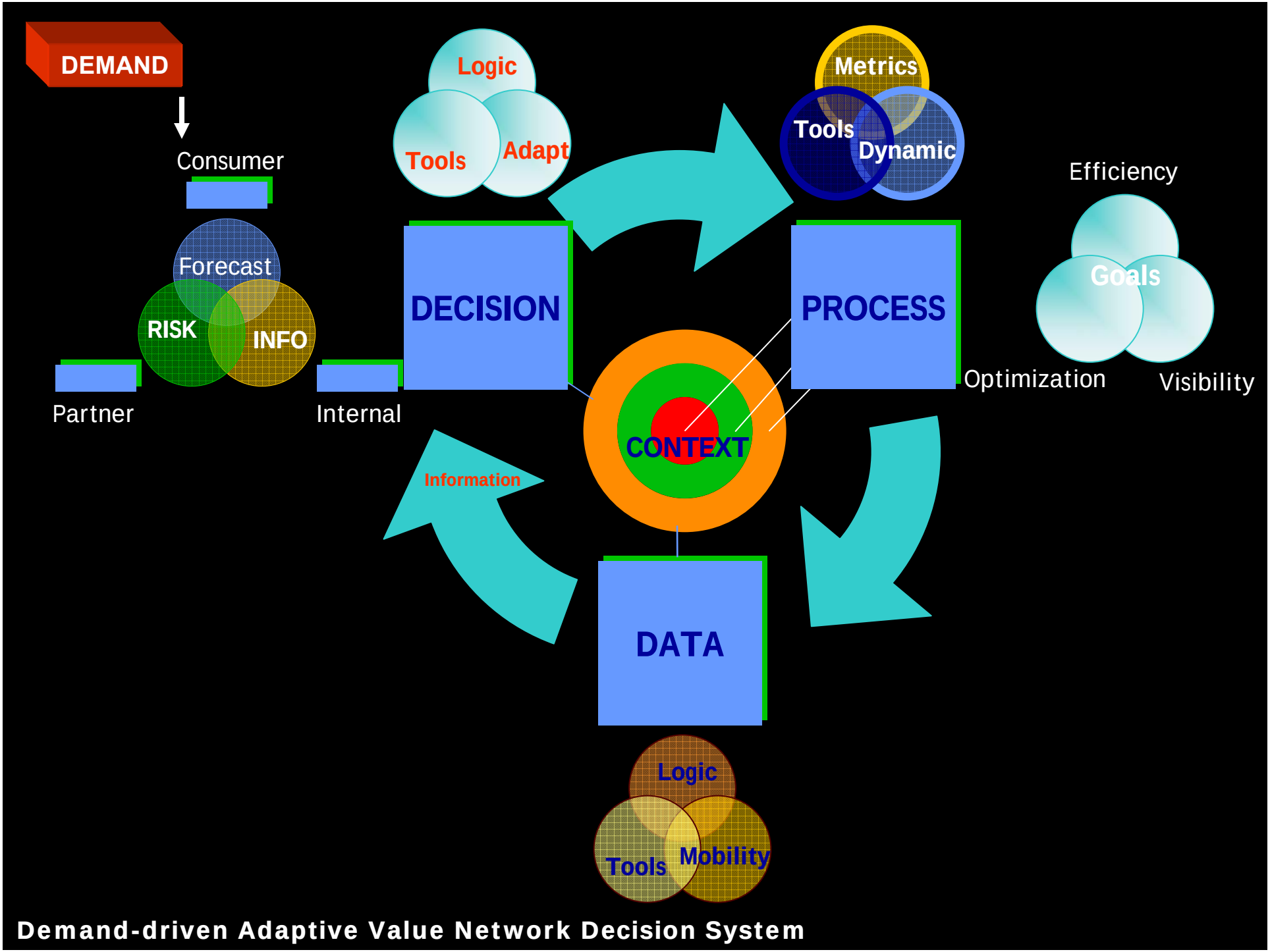


Near-WORST EXAMPLE: Current RFID Usage

Operational Transparency

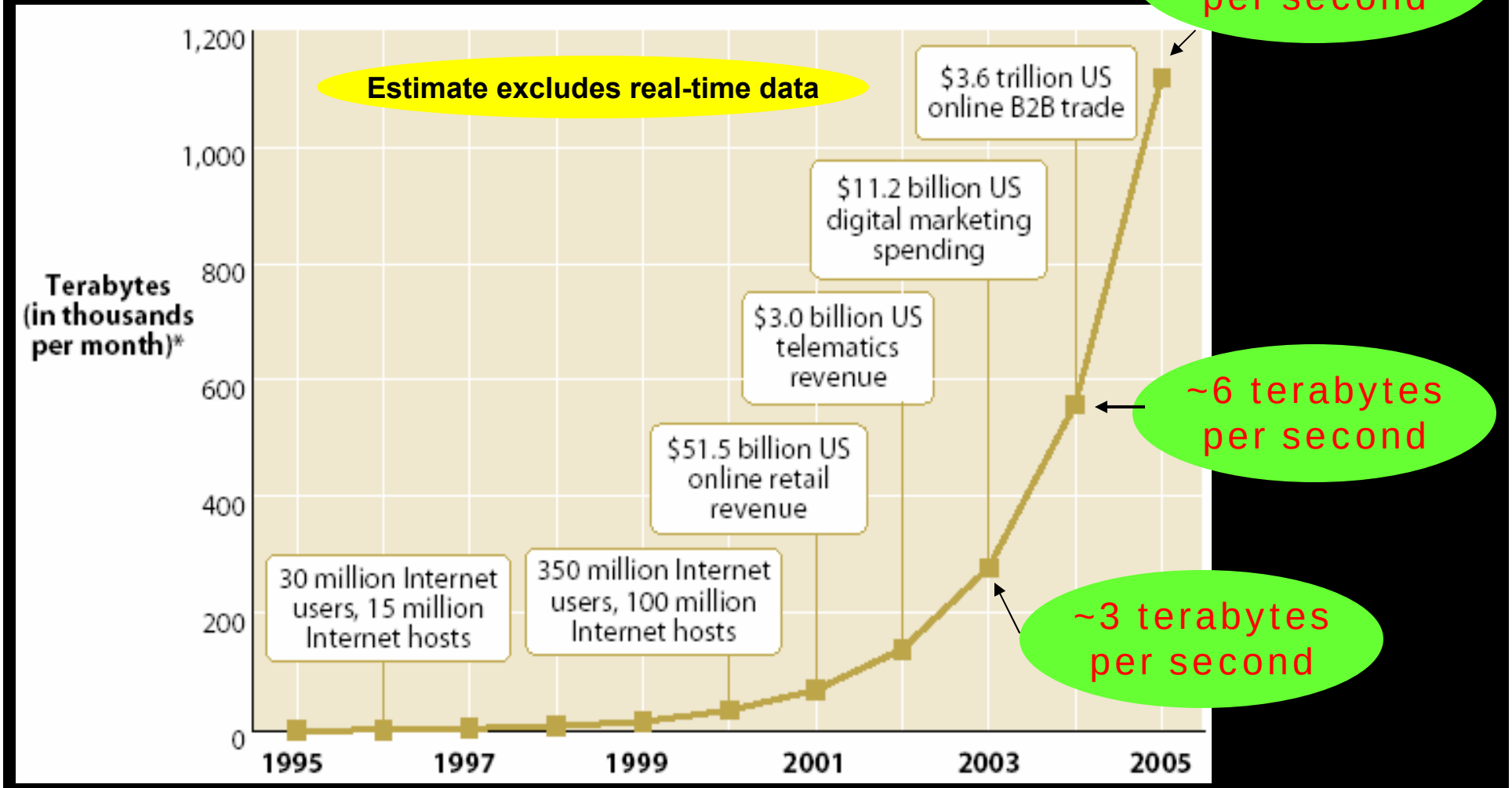


COMPLEMENTARITIES

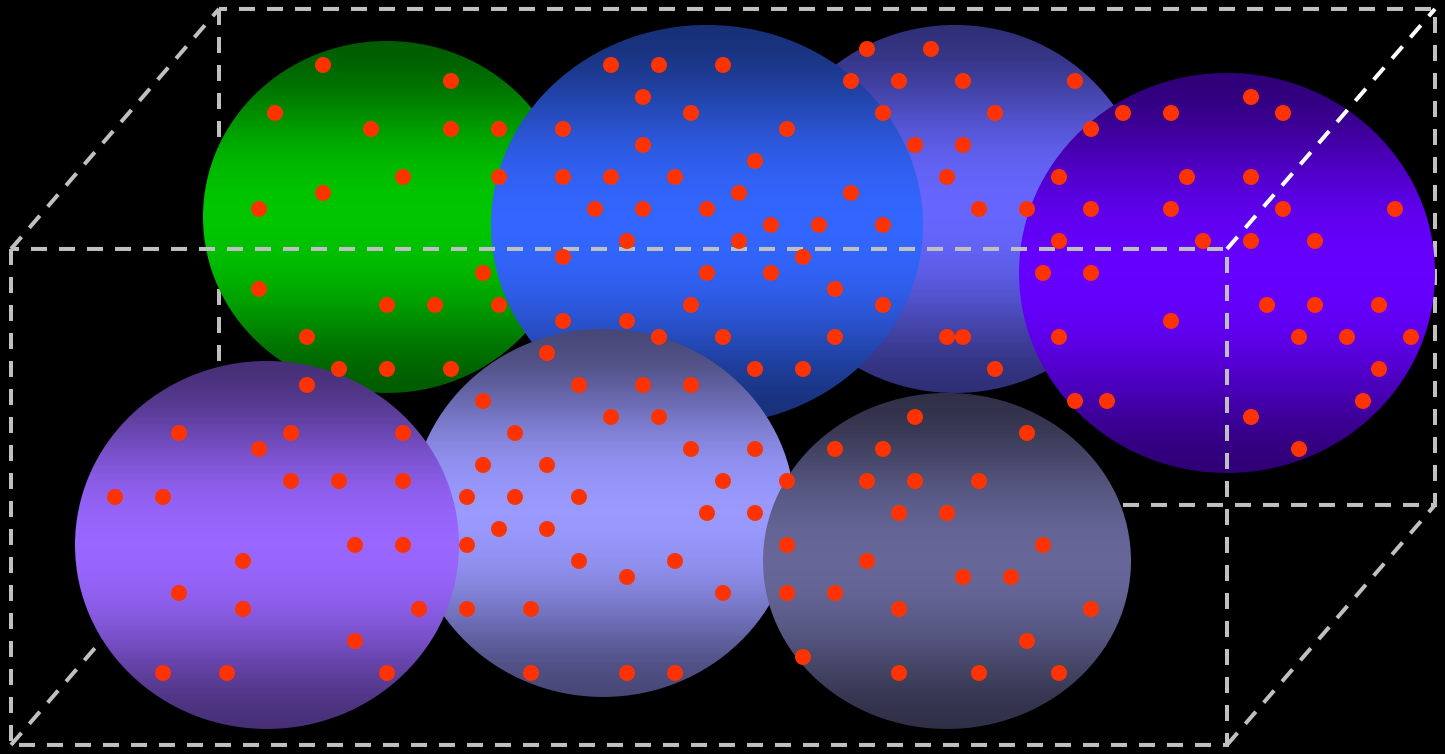

DEMAND
Consumer
Logic
Tools
Adapt
Metrics
Tools
Dynamic
Efficiency
Goals
Forecast
RISK
INFO
DECISION
PROCESS
Optimization
Visibility
Partner
Internal
CONTEXT
Information
DATA
Logic
Tools
Mobility
Demand-driven Adaptive Value Network Decision System

Analytics: Data vs Noise

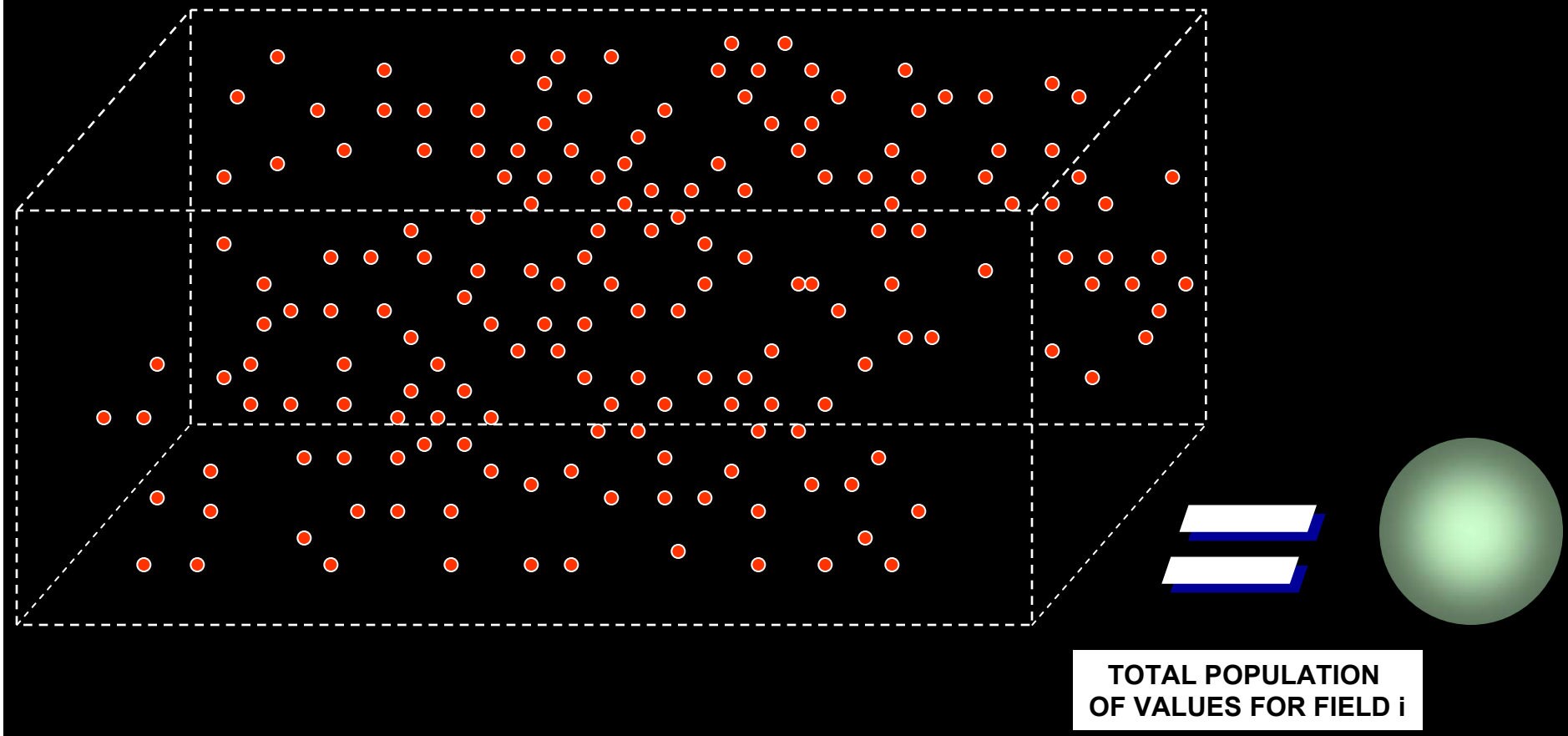
Source: Forrester



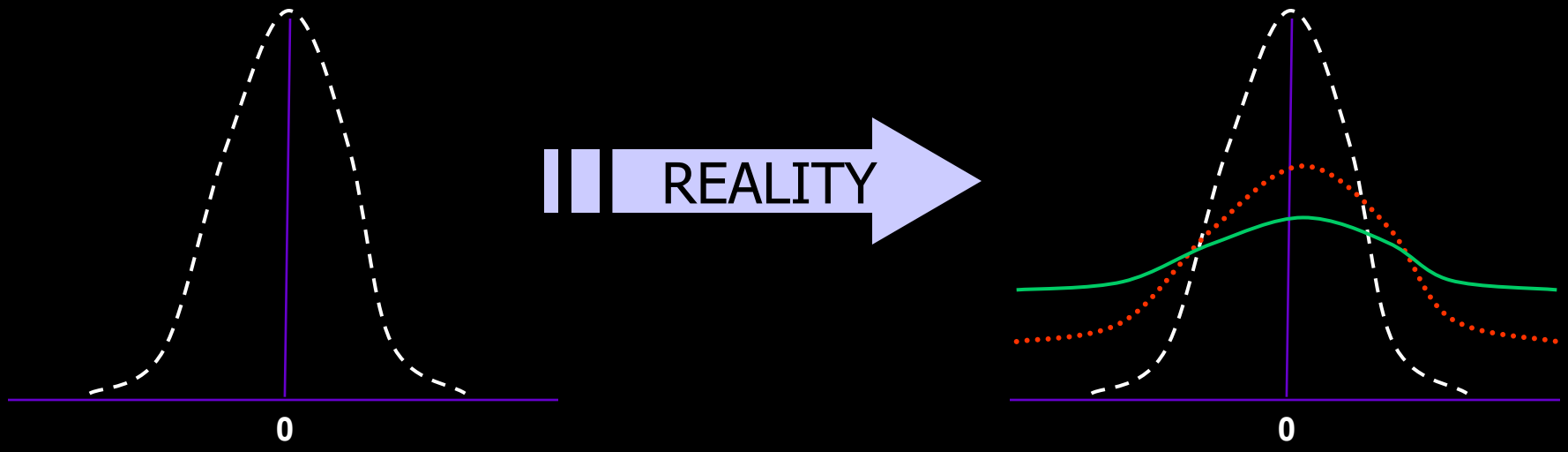
Patterns contained within family of clusters.



Reductionist Approach

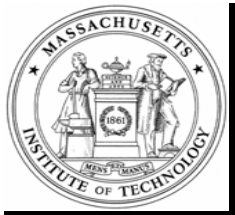


TOTAL POPULATION OF VALUES FOR FIELD i

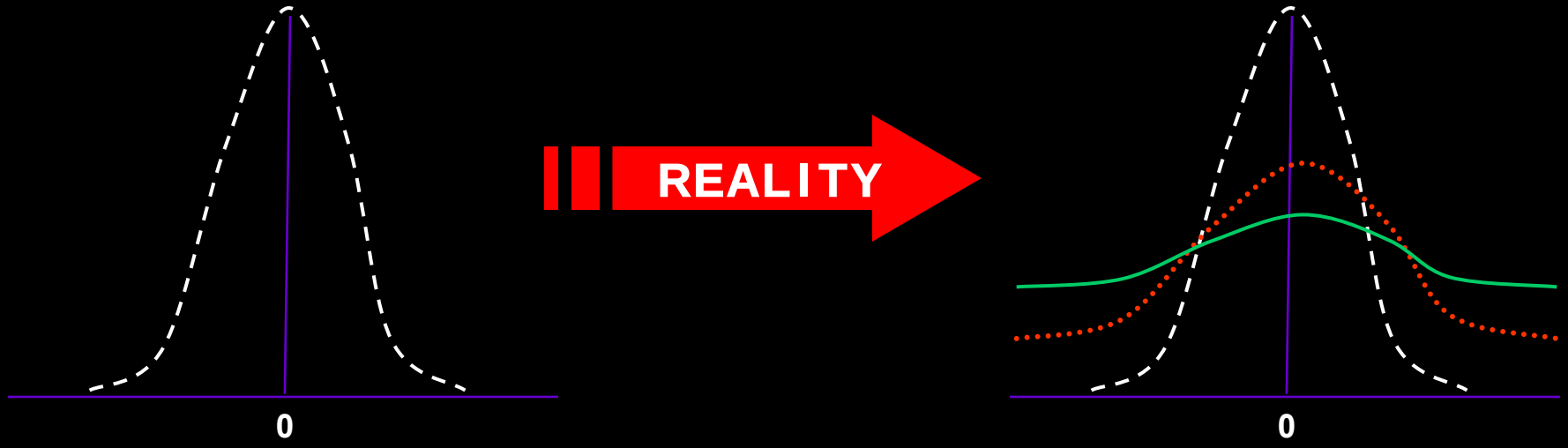


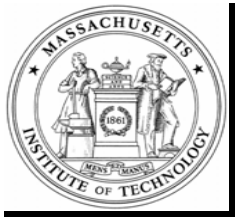
WHAT YOU DO

WHAT YOU IGNORE



Cannot Ignore Errors

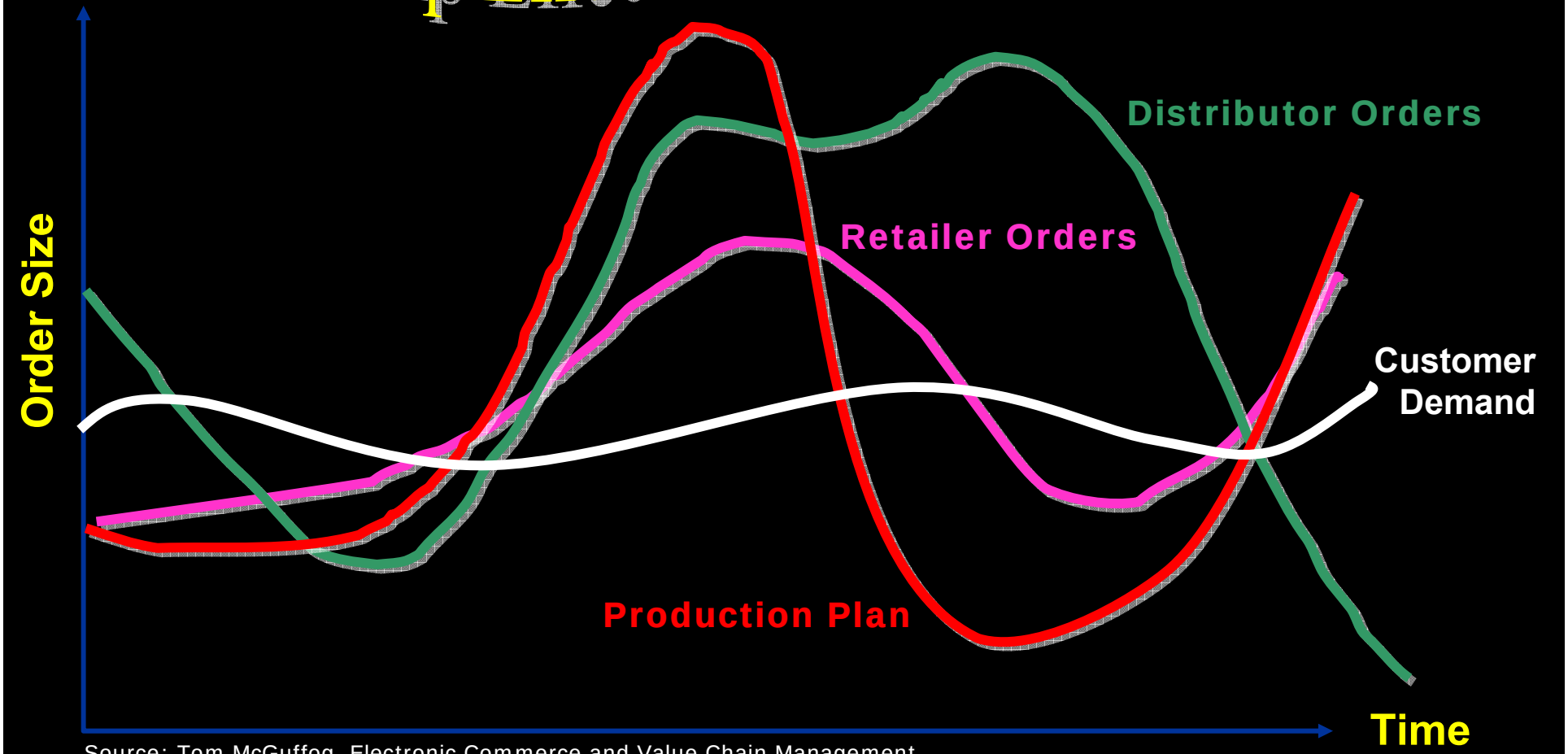




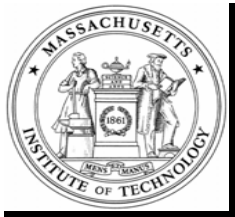
Nobel Prize in Economics 2001 >> Stiglitz, Spence, Ackerloff

Information Asymmetry between Demand and Supply

The Bullwhip Effect

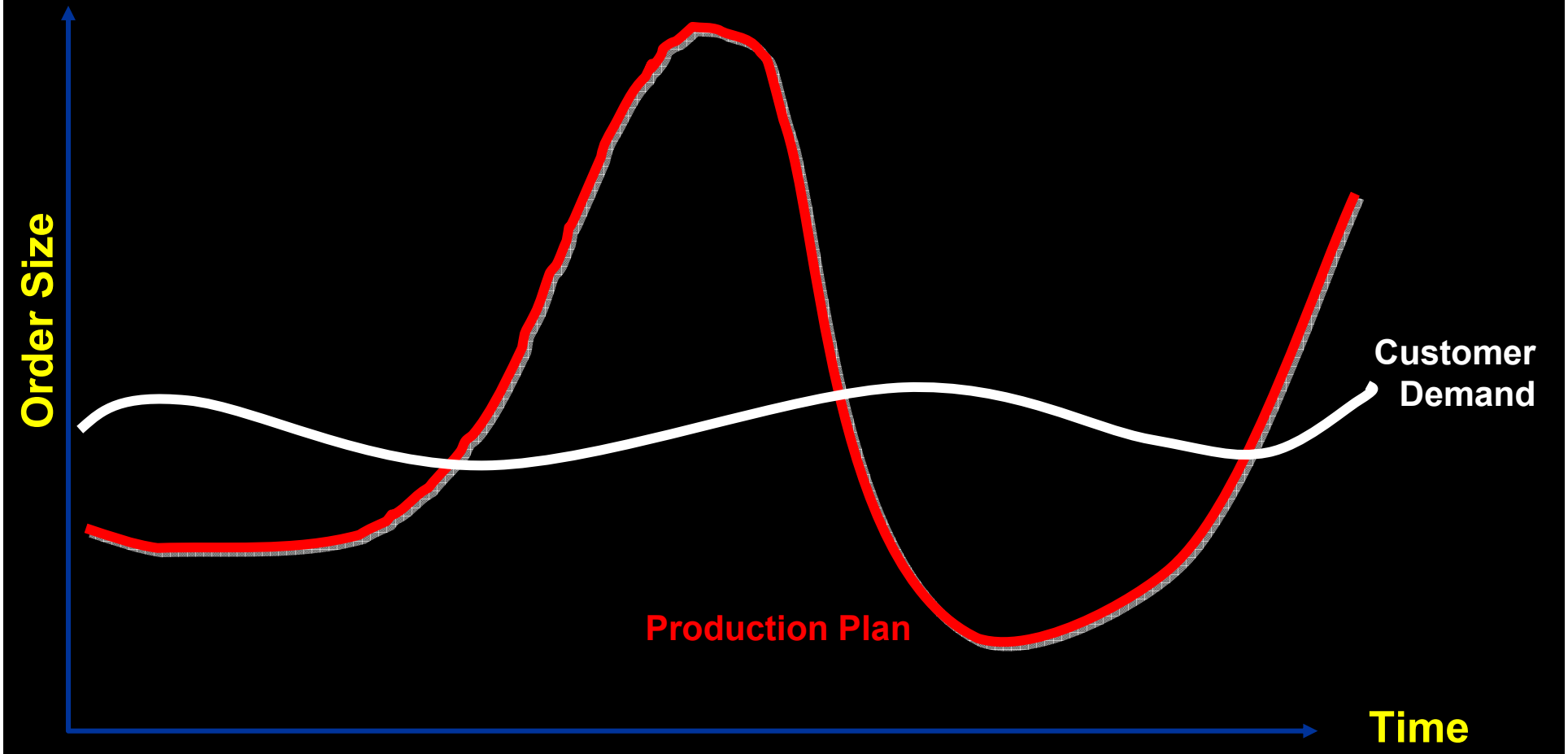


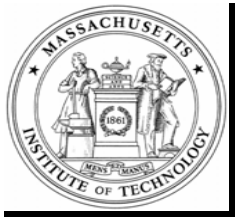
Source: Tom McGuffog, Electronic Commerce and Value Chain Management



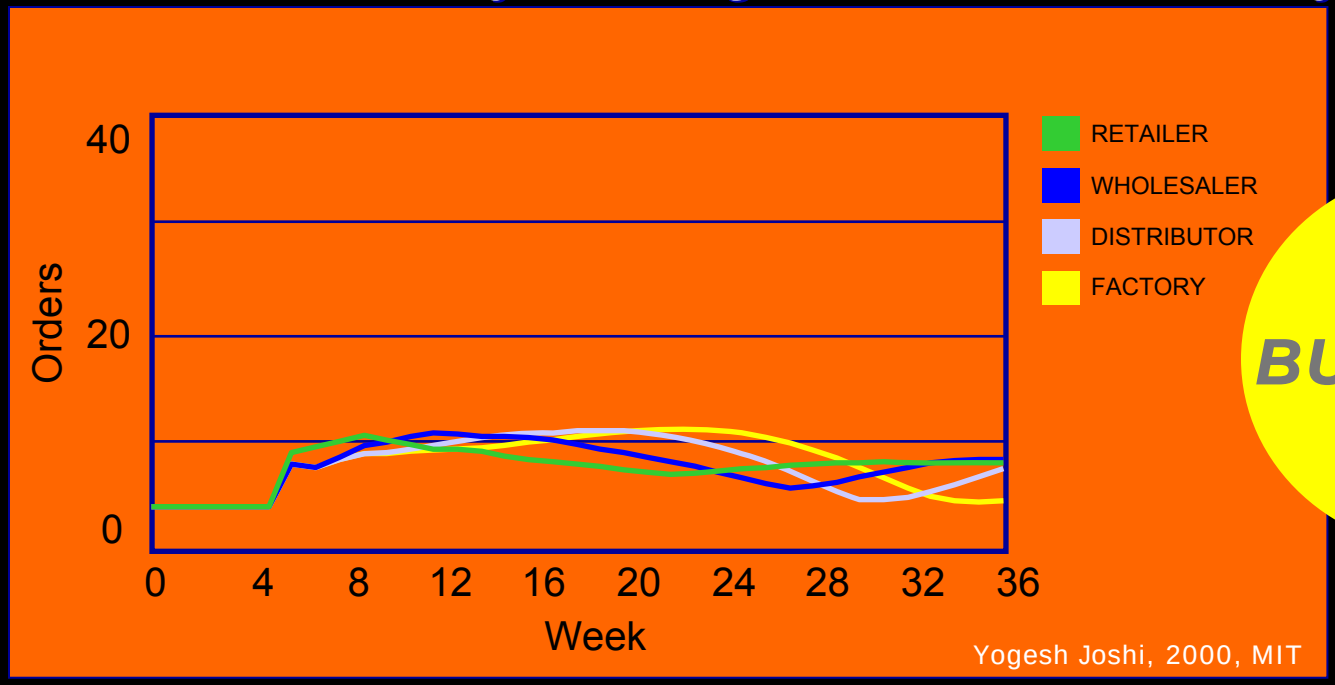
Nobel Prize in Economics 2002 >> Daniel Kahneman & Vernon Smith

Uncertainty





Can real-time data reduce transaction costs?
Can macro-economics predict business cycles?
Can Game Theory strategies reduce volatility?



BULLWHIP

Transaction Cost Economics

Nobel Prize in Economics 1991 >> Ronald Coase

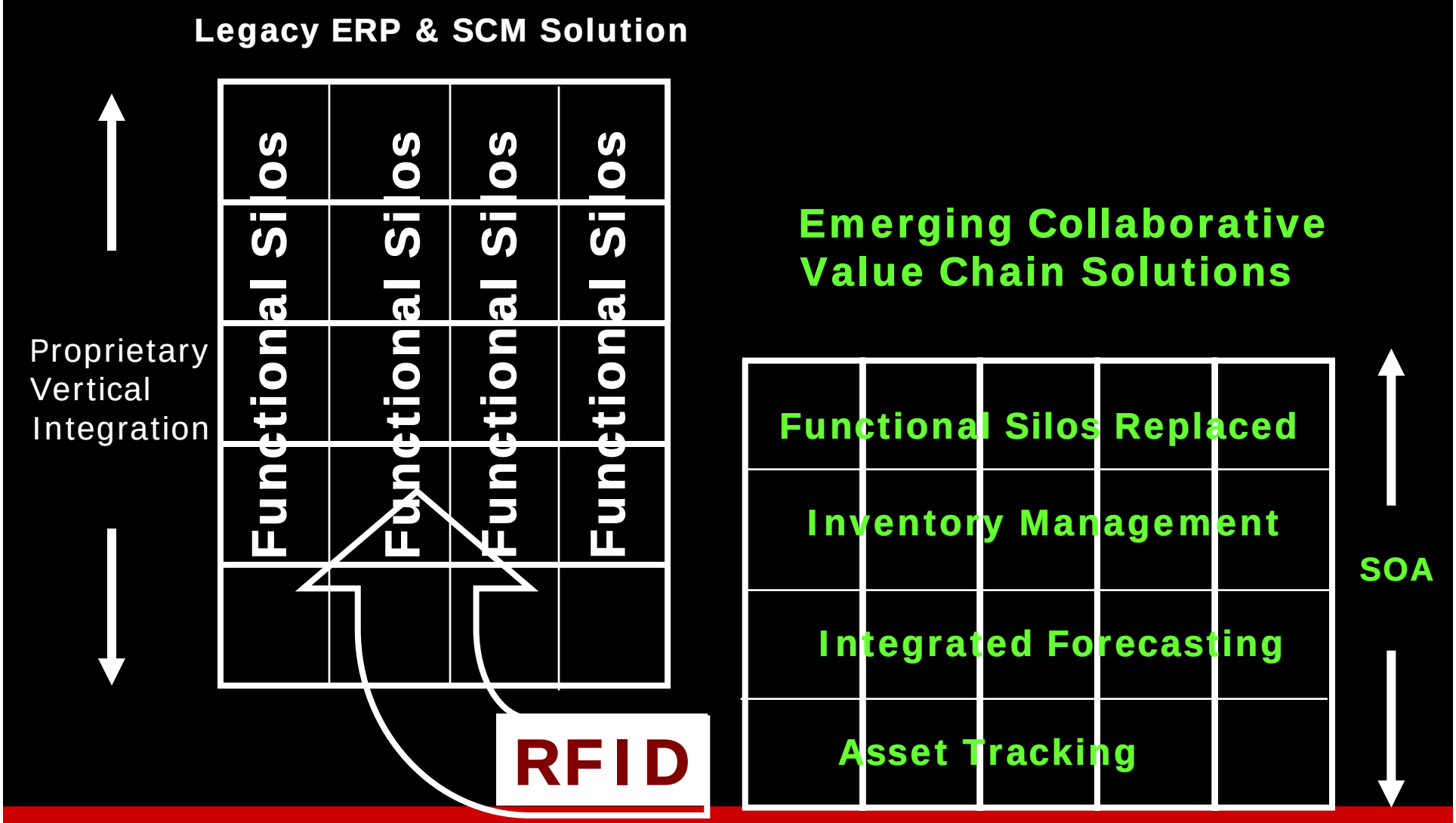
Macroeconomics in Business Cycles

Nobel Prize in Economics 2004 >> Finn Kydland & Edward Prescott

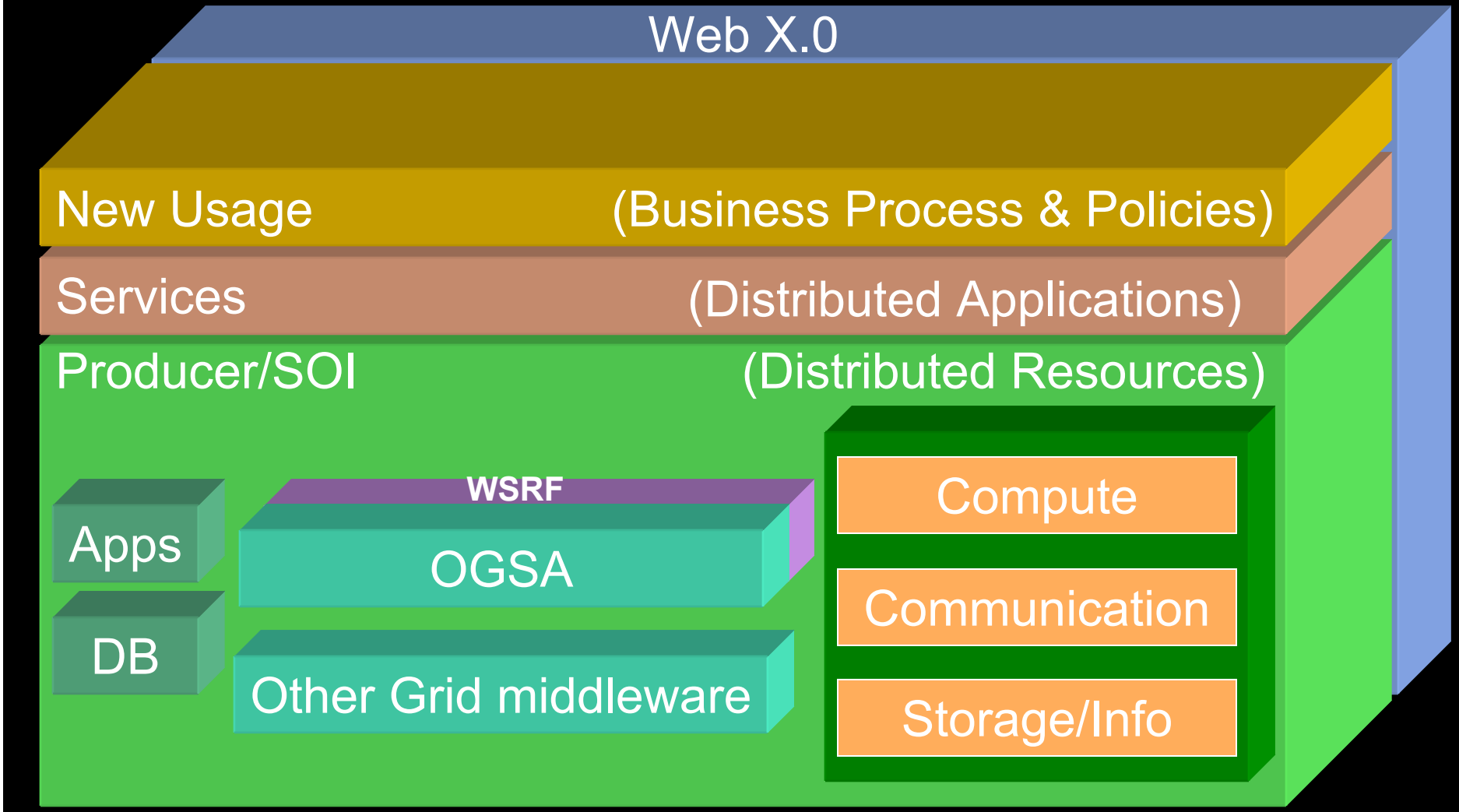
Game Theory Strategies in Cooperation

Nobel Prize in Economics 2005 >> Robert Aumann & Thomas Schelling

RFID Disruption Requires Systems Approach



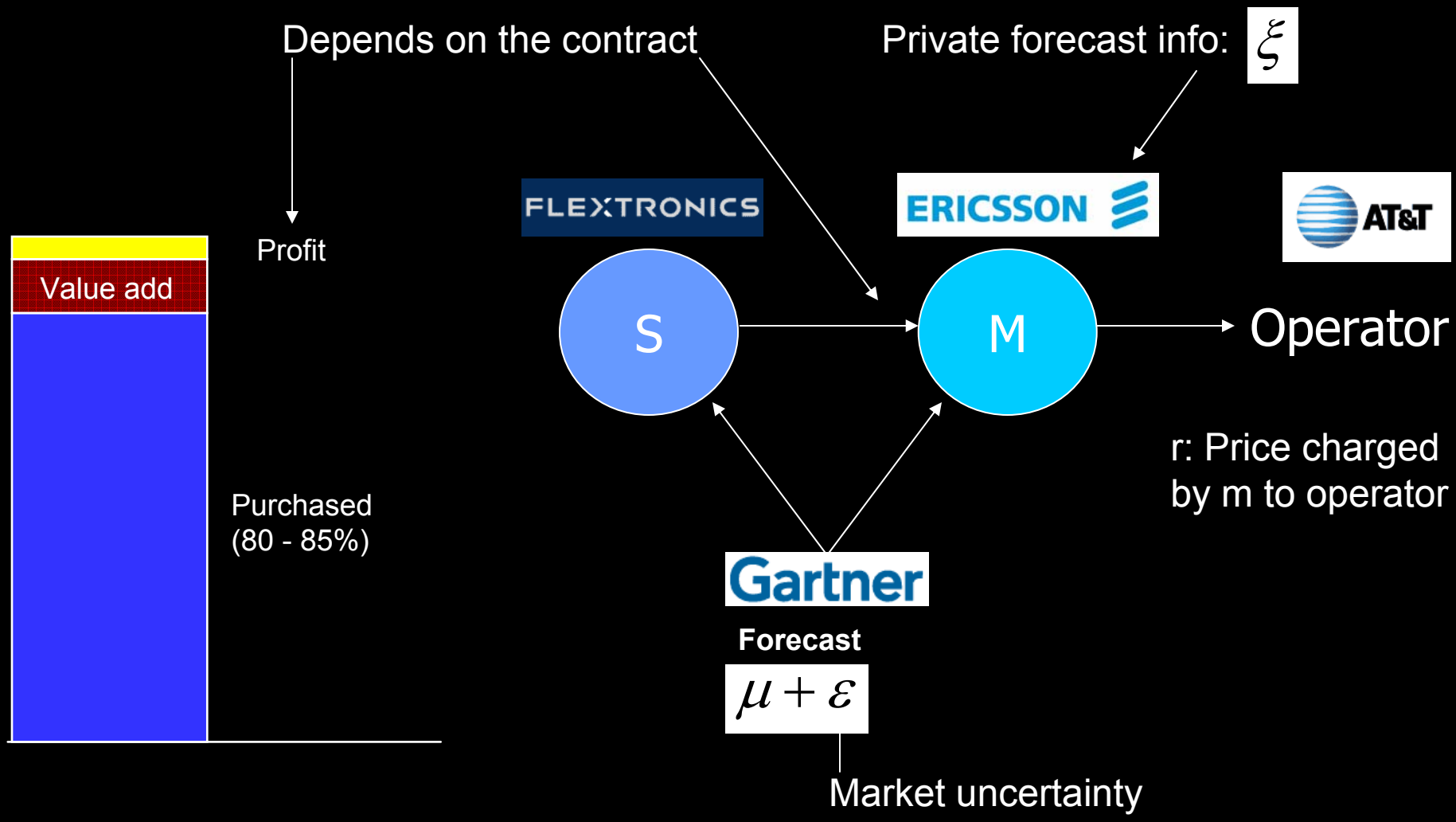
SOA EDGE: Service-Oriented Enterprise



Not there, yet!

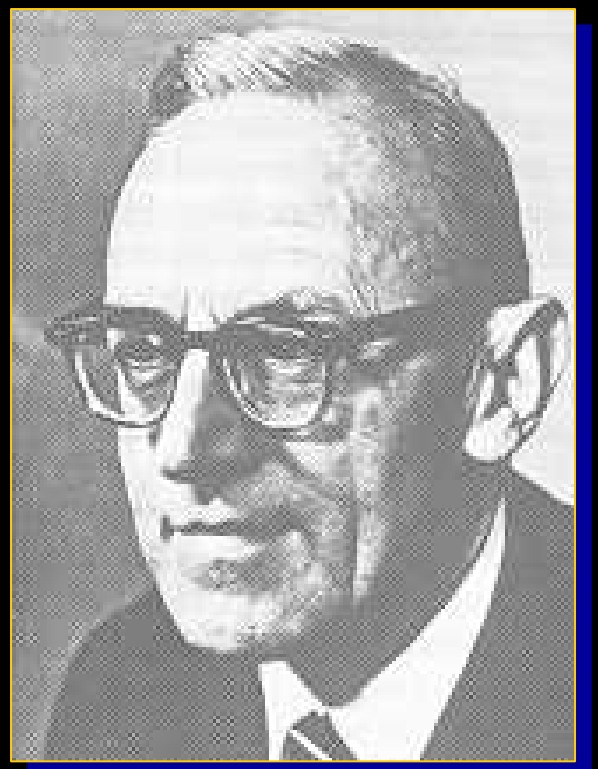
Source: Özalp Özer and Wei Wei

Telecom: Classical Supply Chain Case



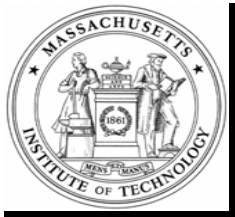
Modern Game Theory (1950)

Jon Von Neumann



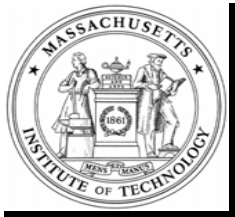
Oskar Morgenstern

- Classical Game Theory (circa 1800, Bertrand and Cournot)
- Commercial use in airline price wars (Stackelberg Equation)
- Nash Equilibrium
- 2005 Nobel Prize for Economics (Aumann & Schelling)



Objective : Reduce Information Asymmetry

- Achieve credible information sharing
- Eliminating sources of inefficiency



Capacity Planning Problem

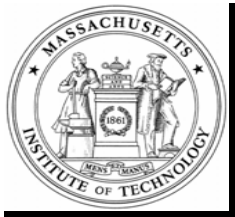
- Short product lifecycle (clockspeed)
- Demand is uncertain prior to capacity decision

$$D = \mu + \xi + \varepsilon$$

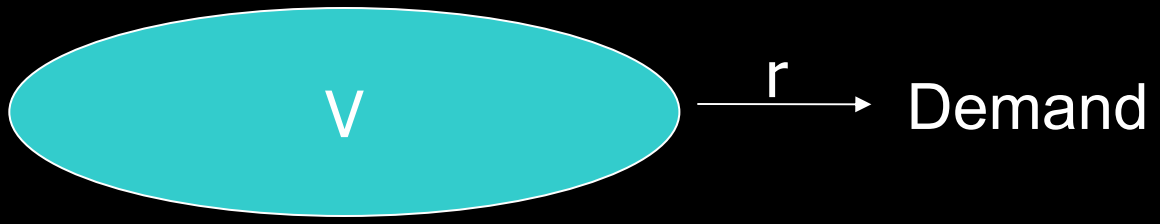
Market uncertainty $\varepsilon \sim G(\cdot)$

Manufacturer's private forecast update

Supplier's prior belief $\xi \in [\underline{\xi}, \overline{\xi}]$ $\xi \sim F(\cdot)$,



Centralized System



Optimization Problem

$$\max_{K \geq 0} E\left[(r-c) \min\left(K, \mu + \xi + \underbrace{\varepsilon}_{random} \right) \right] - c_k K$$

Optimal Capacity

$$K^{cs} = G^{-1}\left(\frac{r-c-c_k}{r-c} \right) + \mu + \xi$$

Decentralized System Wholesale Contract with **Symmetric Information**

- **Manufacturer's profit:**

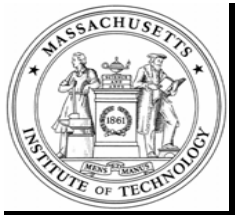
$$(r-w)E\left[\min\left(K, \mu+\xi+\underbrace{\varepsilon}_{random}\right)\right]$$

- **Supplier's optimization problem:**

$$\max_{K\geq 0}(w-c)E\left[\min\left(K, \mu+\xi+\underbrace{\varepsilon}_{random}\right)\right]-c_k K$$

- **Optimal capacity: $K^{ws} < K^{cs}$**

$$K^{ws}=\mu+\xi+G^{-1}\left(\frac{w-c-c_k}{w-c}\right)$$



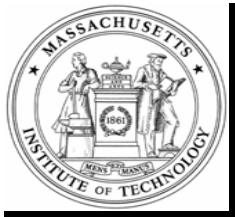
Decentralized System Wholesale Contract with **Asymmetric Information**

- **Supplier's Optimization Problem:**

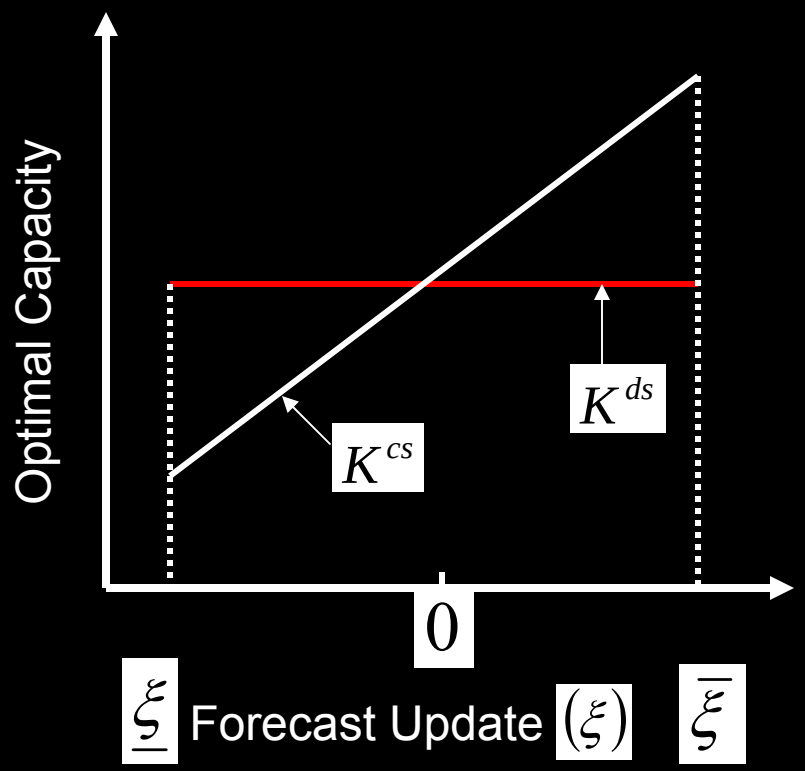
$$\max_{K \geq 0} E\left[(w-c)\min\left(K, \mu + \underbrace{\xi + \varepsilon}_{random} \right) \right] - c_k K$$

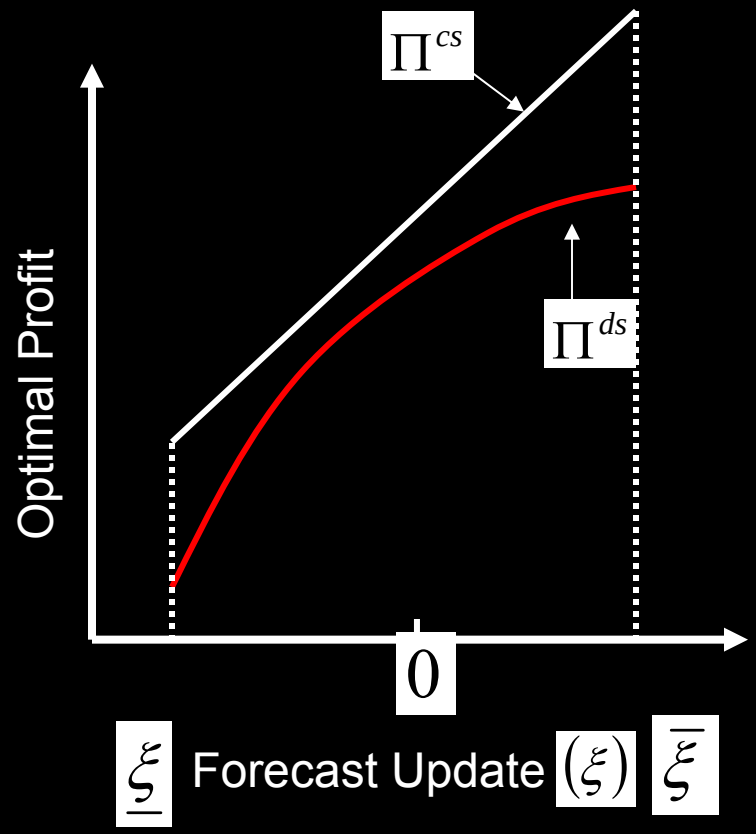
- **Optimal Capacity (in reality):**

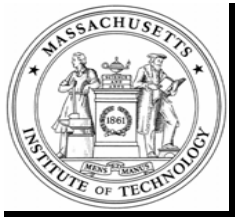
$$K^{ds} = (F \circ G)^{-1}\left(\frac{w-c-c_k}{w-c} \right) + \mu$$



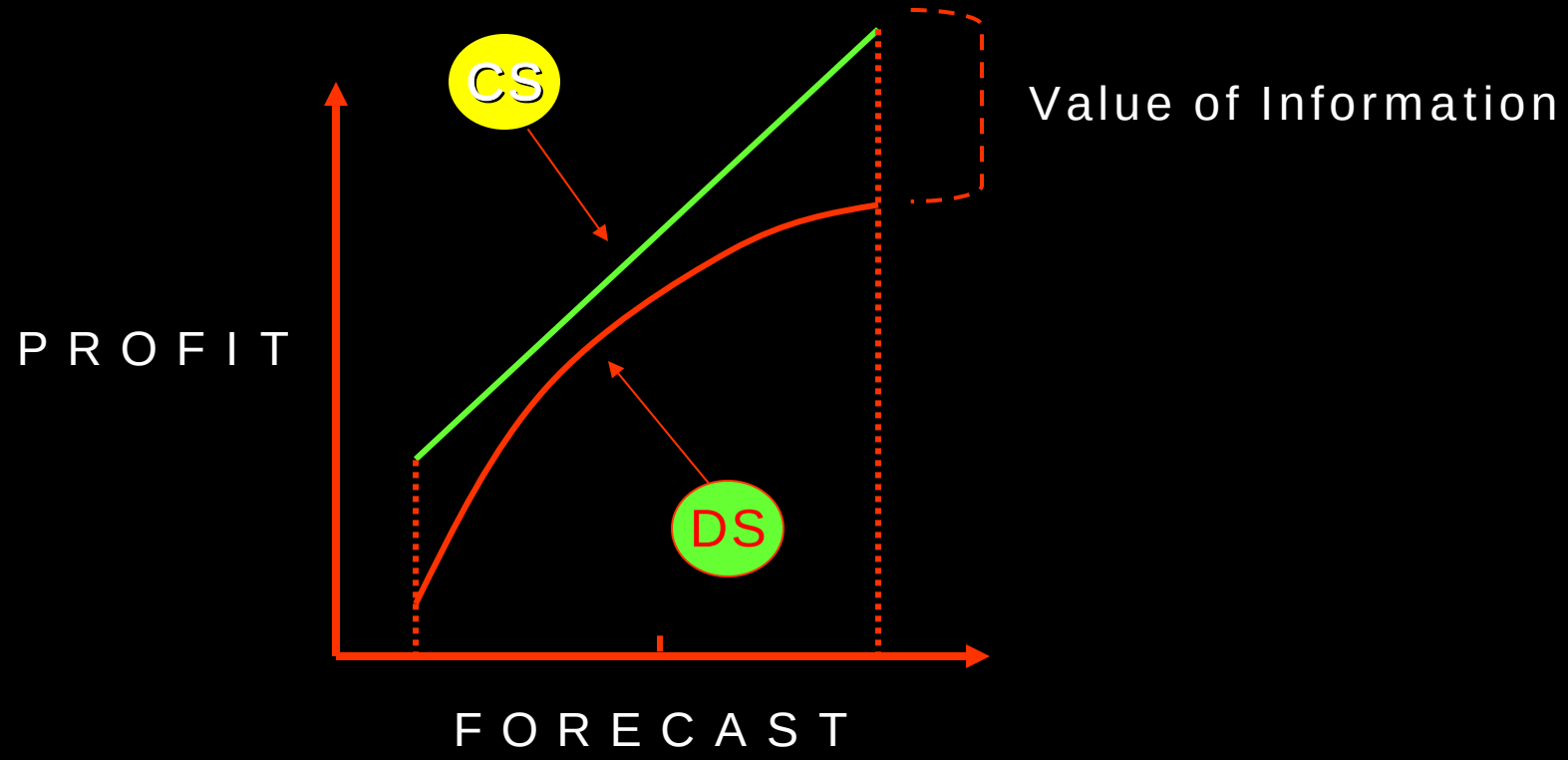
Wholesale Price Contract

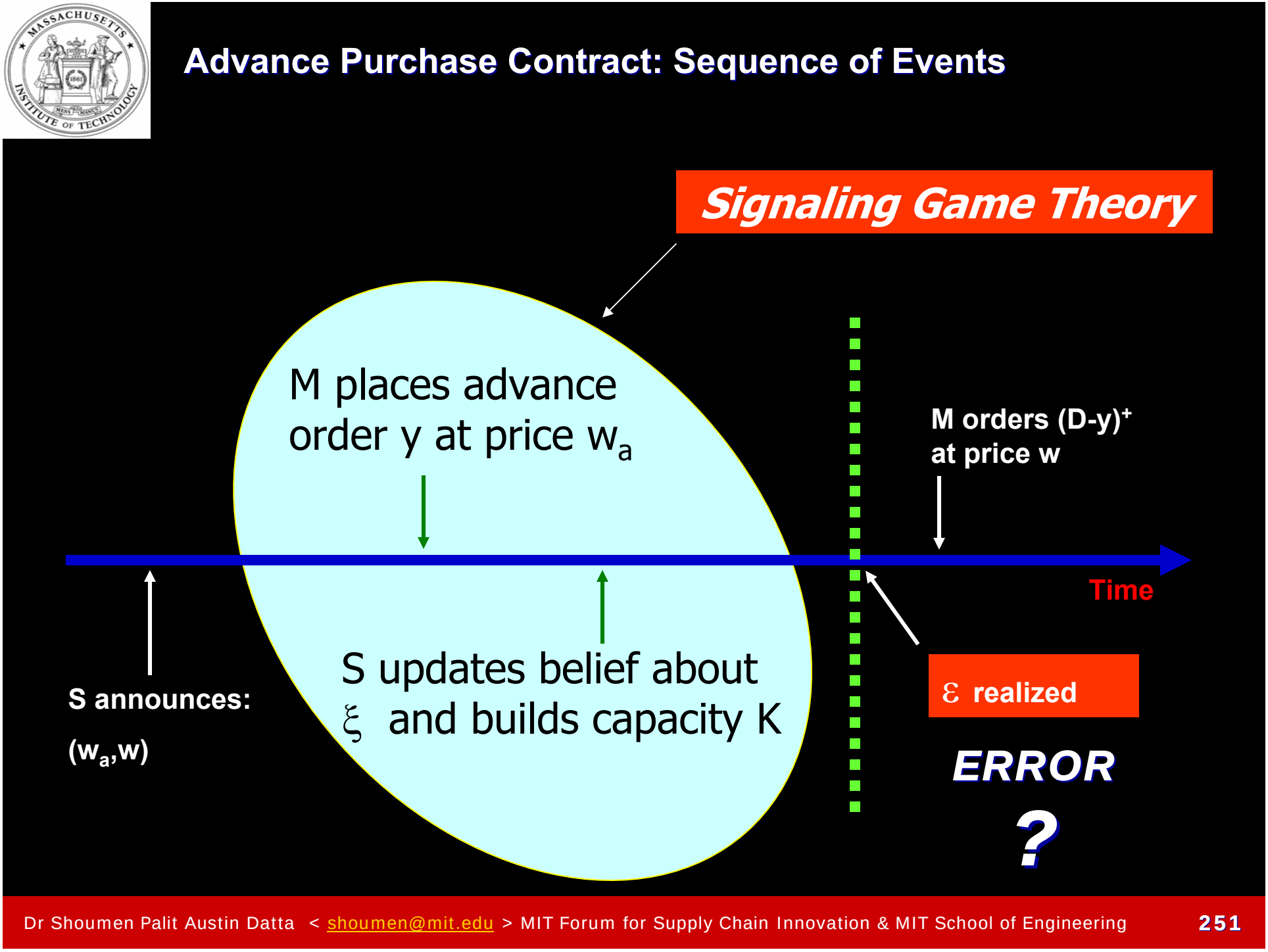






Value of Information




Advance Purchase Contract: Sequence of Events
Signaling Game Theory
M places advance order y at price w_a
M orders $(D-y)^+$ at price w
Time
S announces: (w_a, w)
S updates belief about ξ and builds capacity K
ε realized
ERROR
?

ODD-VAR-GARCH

ODD - Object Data Dependent

VAR - Vector AutoRegression

GARCH - Generalized AutoRegressive Conditional Heteroskedasticity

MGARCH – Multivariate GARCH

Clive Granger and Robert Engle
Nobel Prize in Economics 2003

Forecasting Models

Uncertainty – error terms are assumed to be a distribution

$$D = \mu + \xi + \varepsilon$$

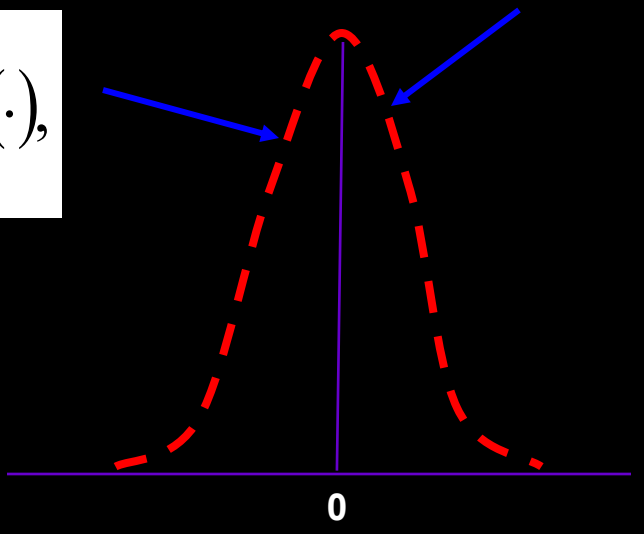
Market uncertainty $\varepsilon \sim \mathrm{G}(\cdot)$

Manufacturer's private forecast update

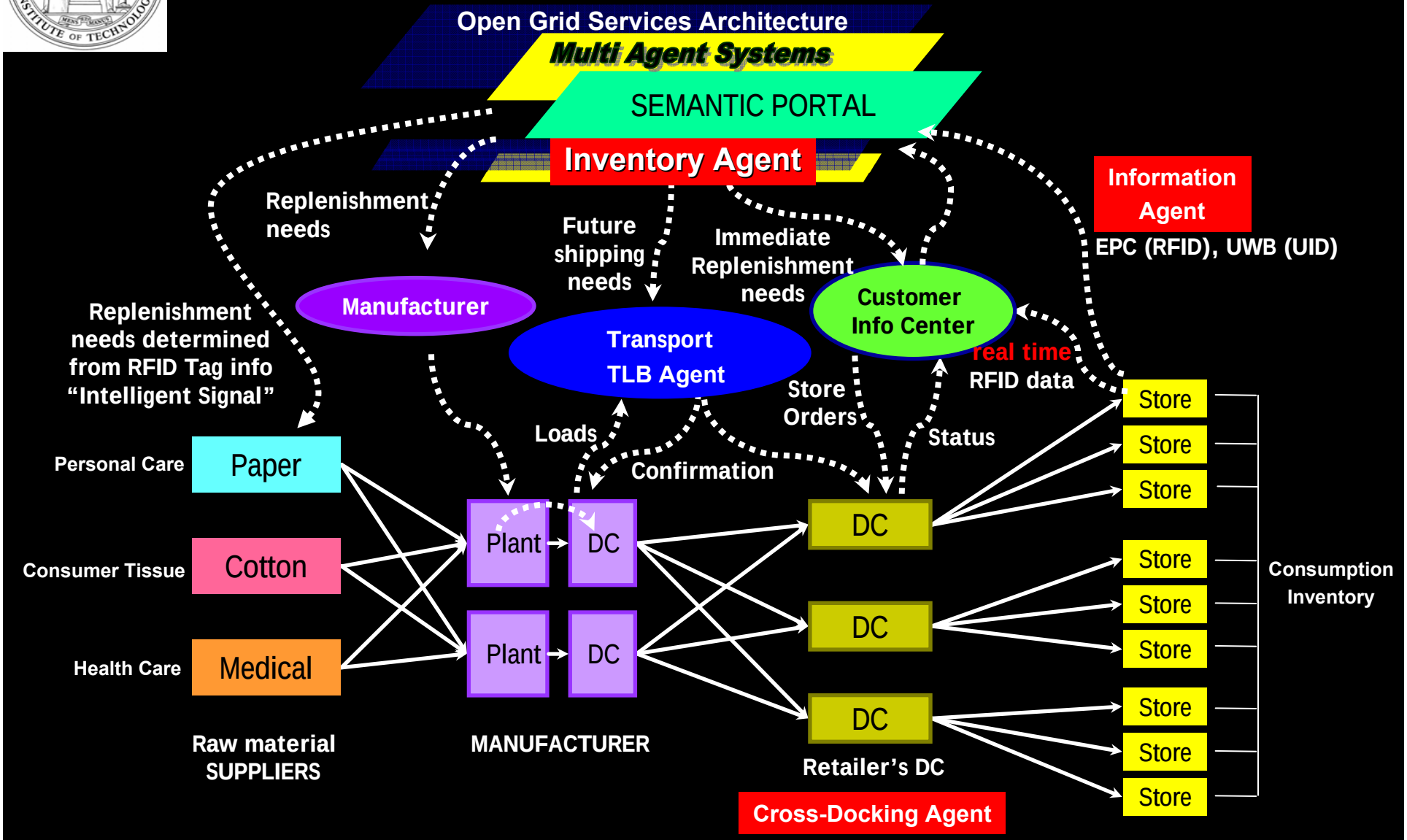
Supplier's prior belief

$\xi \in [\underline{\xi}, \overline{\xi}]$

$\xi \sim F(\cdot)$,



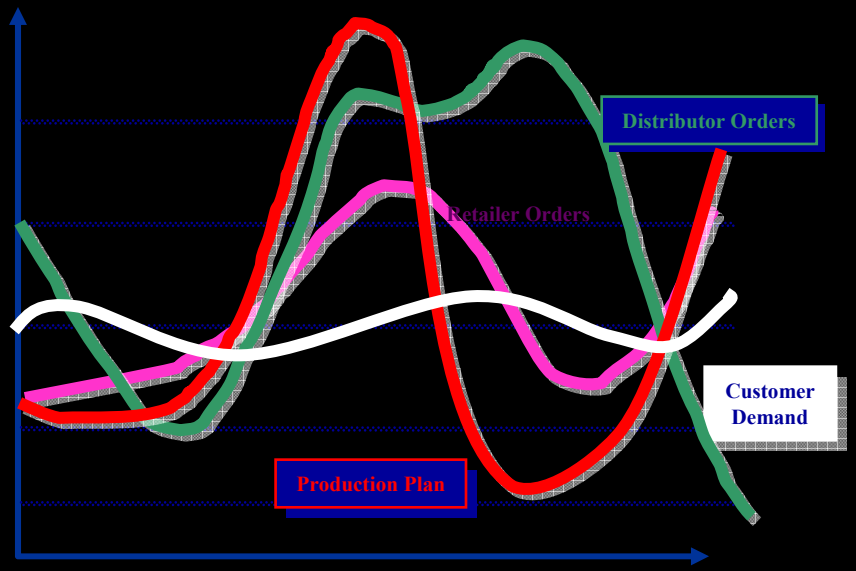
Network: Real-Time Information Lifecycle Management

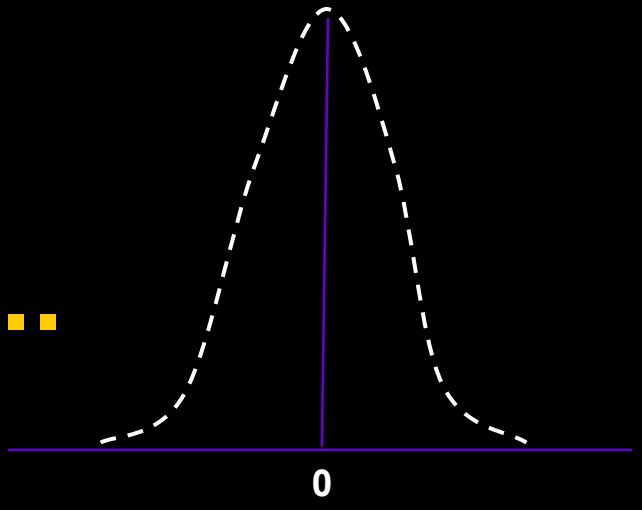


SUM ERROR FROM NETWORK

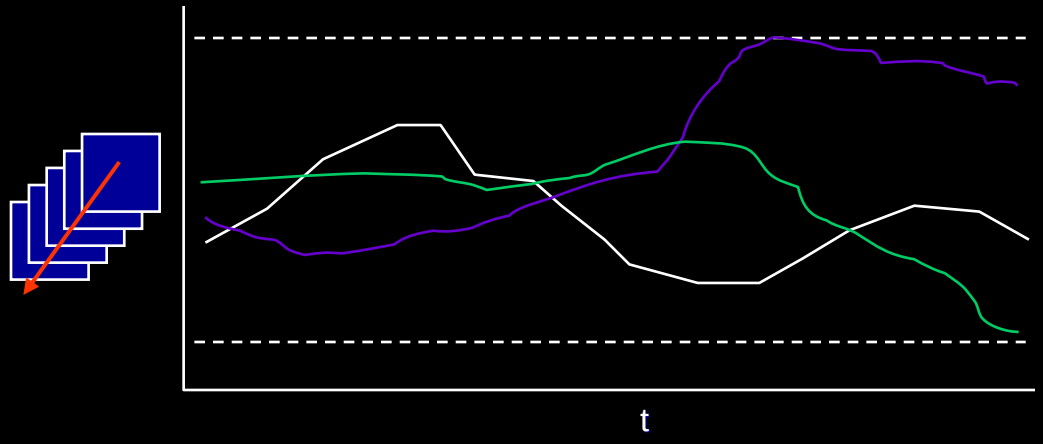
Uncertainty – lumped as a non-variant (homo-skedastic) constant

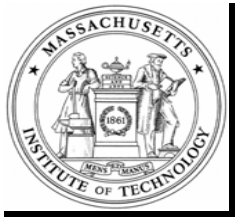
$$y_t = \beta_0 + \sum_{j=1}^{N_y} \varphi_j y_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki}\, x_{kt-i} + \varepsilon_t$$



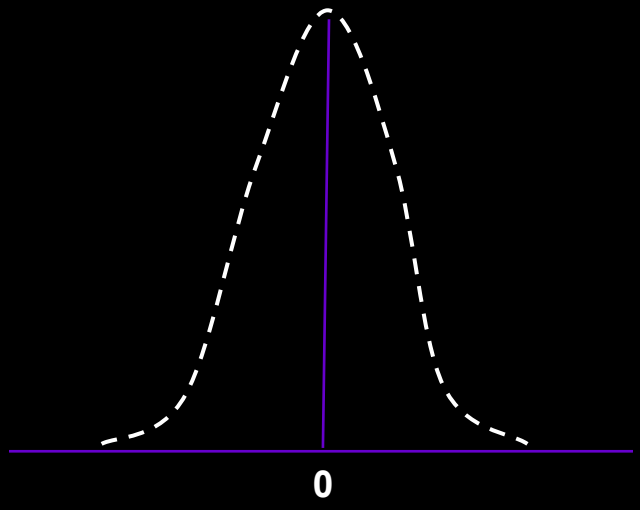


Looking "across" recent history of same SKU

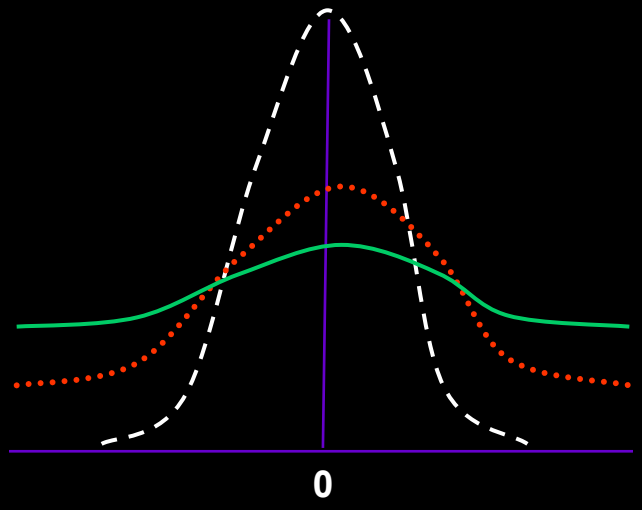




Volatility



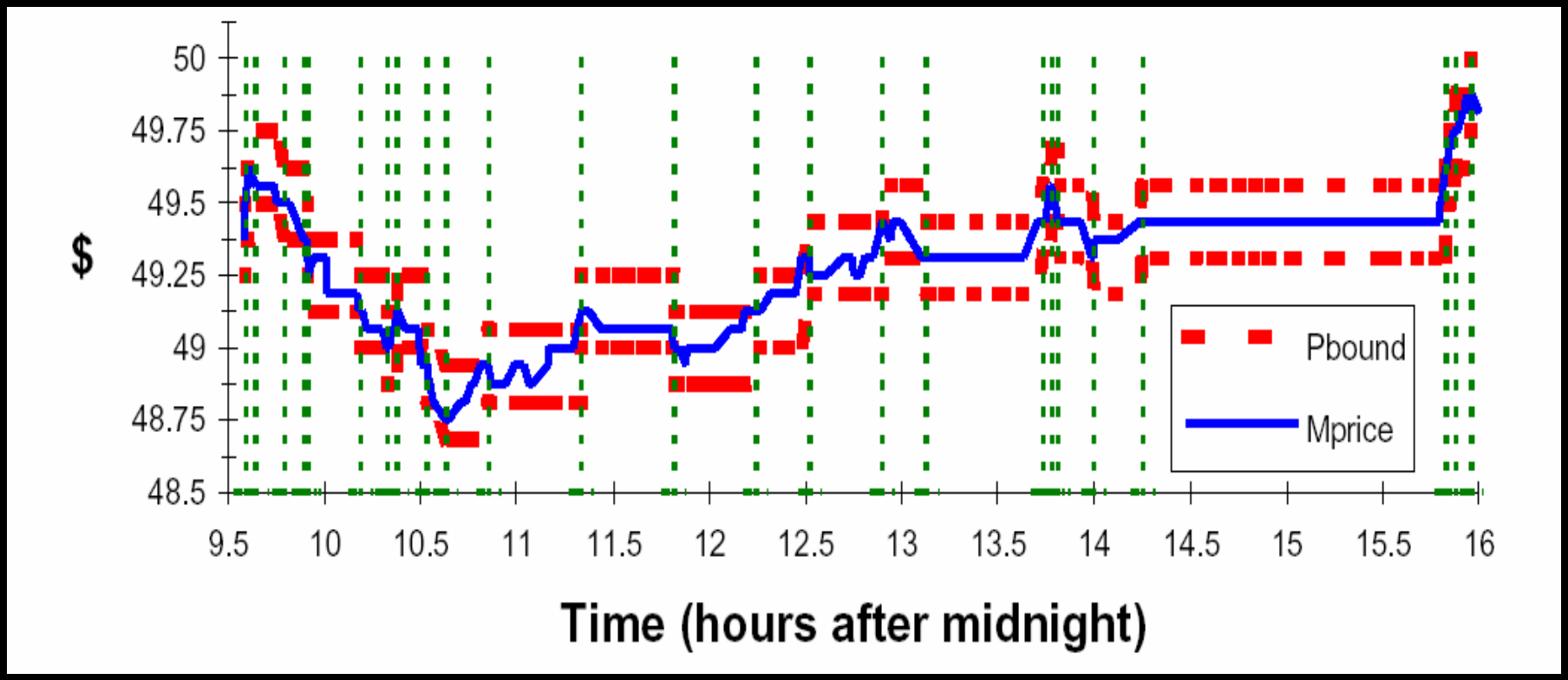
Homoskedastic



Heteroskedastic

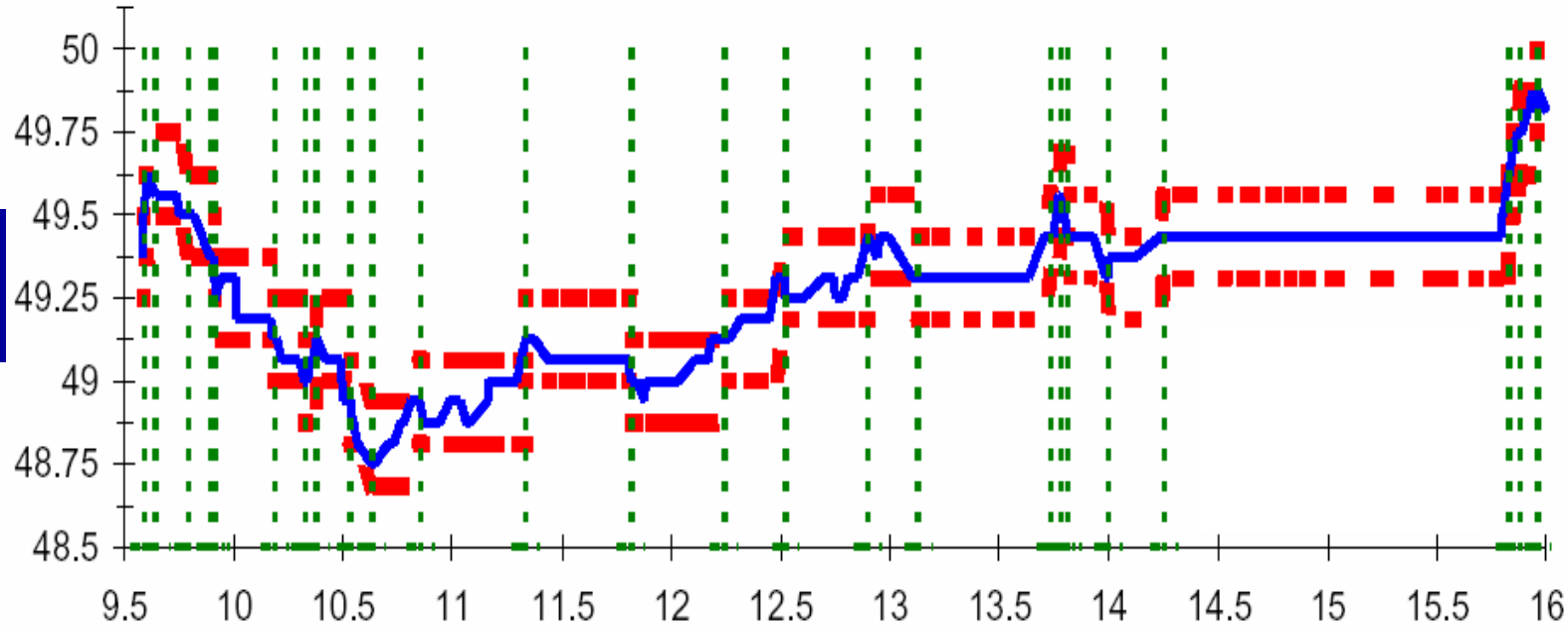
homo = same
skedasticity = variance

NYSE quotes for Exxon on 01 November 2001



Source: New York Stock Exchange and Robert Engle, New York University

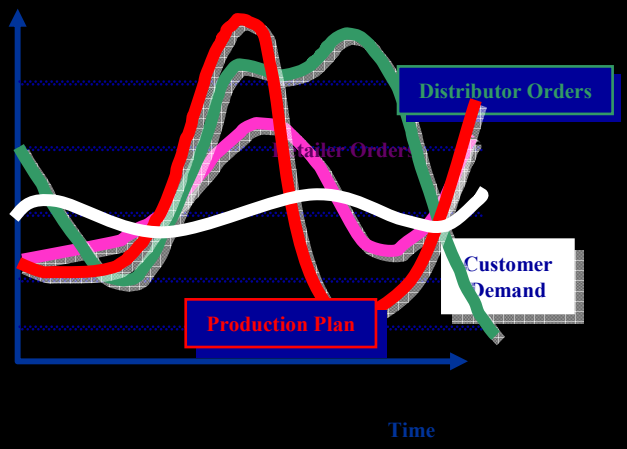
RFID Data ? Sensor Network Data ?

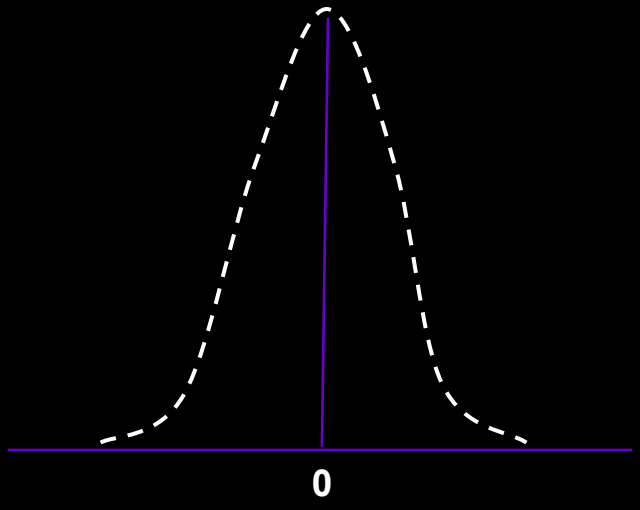


ERROR TERM

Uncertainty – lumped as a non-variant (homo-skedastic) constant

$$y_t = \beta_0 + \sum_{j=1}^{N_y} \varphi_j y_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki}\, x_{kt-i} + \varepsilon_t$$



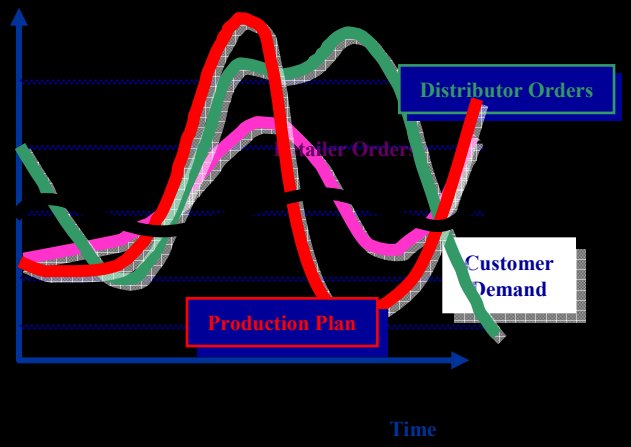


ARCH

Granger & Engle captures the time varying volatility of the random error term

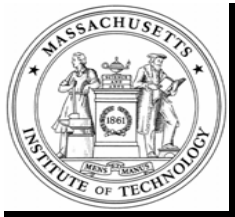
AutoRegressive Conditional Heteroskedasticity (Granger & Engle, Nobel Prize in Economics, 2003)

$$y_t = \beta_0 + \sum_{j=1}^{N_y} \varphi_j y_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varepsilon_t$$



Variance of random error term over time depends on previous lagged errors (t-1, t-2, …., t-q)

$$\sigma_t^2 = \theta_0 + \theta_1 \varepsilon^2_{t-1} + \theta_2 \varepsilon^2_{t-2} + \ldots + \theta_q \varepsilon^2_{t-q}$$



GARCH

Generalized AutoRegressive Conditional Heteroskedasticity

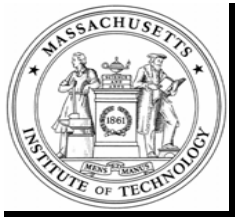
$$y_t = \beta_0 + \sum_{j=1}^{N_y} \varphi_j y_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varepsilon_t$$

$$\sigma_t^2 = \theta_0 + \theta_1 \varepsilon^2_{t-1} + \theta_2 \varepsilon^2_{t-2} + \ldots + \theta_q \varepsilon^2_{t-q}$$

Variance of the random error term DEPENDS NOT ONLY on previous lagged errors (t-1, t-2, …., t-q) but also on LAGGED VALES OF THE VARIANCE (t-1, t-2, …, t-p)

$$y_t = \beta_0 + \sum_{j=1}^{N_y} \varphi_j y_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varepsilon_t$$

$$\sigma_t^2 = \theta_0 + \sum_{i=1}^{q} \theta_i \varepsilon^2_{t-i} + \sum_{j=1}^{p} \tau_j \sigma^2_{t-j}$$



Network > Supply Chain Effect
Vector AutoRegression (VAR) + GARCH

n = 2, p = 1
2 locations
1 lag period
Single SKU

$$y_{1t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{11} y_{1t-1} + \varphi_{12} y_{2t-1} + \varepsilon_{1t}$$

$$y_{2t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{21} y_{1t-1} + \varphi_{22} y_{2t-1} + \varepsilon_{2t}$$

$$\sigma_{1t}^2 = \theta_0 + \sum_{i=1}^{q} \theta_i \varepsilon^2_{1t-i} + \sum_{j=1}^{p} \tau_j \sigma^2_{1t-j}$$

$$\sigma_{2t}^2 = \theta_0 + \sum_{i=1}^{q} \theta_i \varepsilon^2_{2t-i} + \sum_{j=1}^{p} \tau_j \sigma^2_{2t-j}$$

VAR-GARCH

ROI from very high volume auto id data

n = 10; p = 1,000
10 locations
1,000 lags

Estimate Coefficients:

10,000 φ
+
10,000 for x's
=
20,000 per stage
or
200,000 for n=10
(excluding constants and error coefficients)

$$y_{1t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{11} y_{1t-1} + \varphi_{12} y_{2t-1} + \varepsilon_{1t}$$

$$y_{2t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{21} y_{1t-1} + \varphi_{22} y_{2t-1} + \varepsilon_{2t}$$

$$\sigma_{1t}^2 = \theta_0 + \sum_{i=1}^{q} \theta_i \varepsilon^2_{1t-i} + \sum_{j=1}^{p} \tau_j \sigma^2_{1t-j}$$

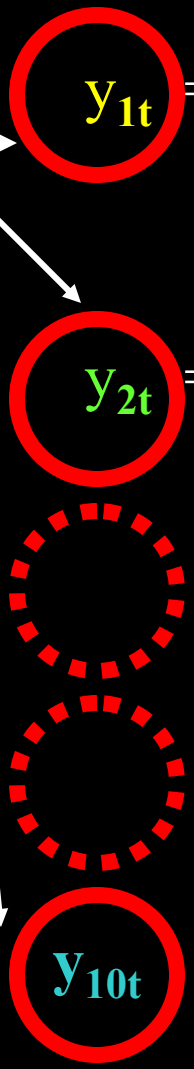
$$\sigma_{2t}^2 = \theta_0 + \sum_{i=1}^{q} \theta_i \varepsilon^2_{2t-i} + \sum_{j=1}^{p} \tau_j \sigma^2_{2t-j}$$

VAR-GARCH

Auto id nodes in Supply Network Planning

n = 10; p = 1,000

10 locations



$$y_{1t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{11} y_{1t-1} + \varphi_{12} y_{2t-1} + \varepsilon_{1t}$$

$$y_{2t} = \beta_0 + \sum_{k=1}^{K} \sum_{i=1}^{N_{x_{kt}}} \alpha_{ki} x_{kt-i} + \varphi_{21} y_{1t-1} + \varphi_{22} y_{2t-1} + \varepsilon_{2t}$$

y_{10t}

Will ROI increase if business process is optimized before tech investment?

Will precision of forecasting depend on an optimized supply network planning?

Transforming EBM to ABM

Cross-docking Variables: Decouple 'Chains' to Include/Exclude Local Effects

Traditional EBM (CLRM example): Sales of Aspirin and Variables that Impact Sales

EBM - Explanatory Variables

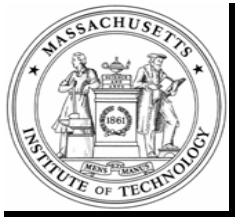
Example of X:
[1] Inventory
[2] Price
[K] Expiration

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_K x_{Kt} + \varepsilon_t$$

Inventory Agent | Price Agent | Expiration Agent

ABM - Agents in EBM DSS

Transformed EBM plus ABM within CLRM construct: Sales of Aspirin



Decoupling Equation-Based Models (EBM) prevalent in SCM

Agent-integrated business models rapidly respond to changes in value network partners and incorporate local changes for global optimization.

Inventory Price Expiration

MODEL 1

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_K x_{Kt} + \varepsilon_t$$

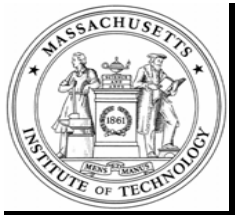
MODEL 2

$$y_t = \beta_0 + \beta_1 x_{1t} + \square + \ldots + \beta_K x_{Kt} + \varepsilon_t$$

MODEL 3

$$y_t = \beta_0 + \beta_1 x_{1t} + a_2 z_{2t} + \ldots + \beta_K x_{Kt} + \varepsilon_t$$

CROSS-DOCKING VARIABLES



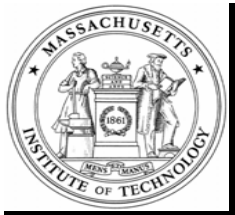
VAR-GARCH (+ ABM) : Real World Behaviour

Real world outcomes are influenced by events or interactions between decision domains (supply chain or value network partners). Coefficient φ_{ij} refers to changes in y_i with respect to y_j (hence, importance of SNP).

For example, if y_1 represents Michelin tire sales at Sears retail store and y_2 represents Michelin tire sales at the distributor, Merisel, then parameter φ_{12} refers to changes in sales at retail store (y_1) with respect to sales at the distributor (y_2).

Random error term (ε_{1t} and ε_{2t}) volatility will impact both dependent variables (y_1 and y_2). Uncertainty in the sales at retail store impact sales at the distributor.

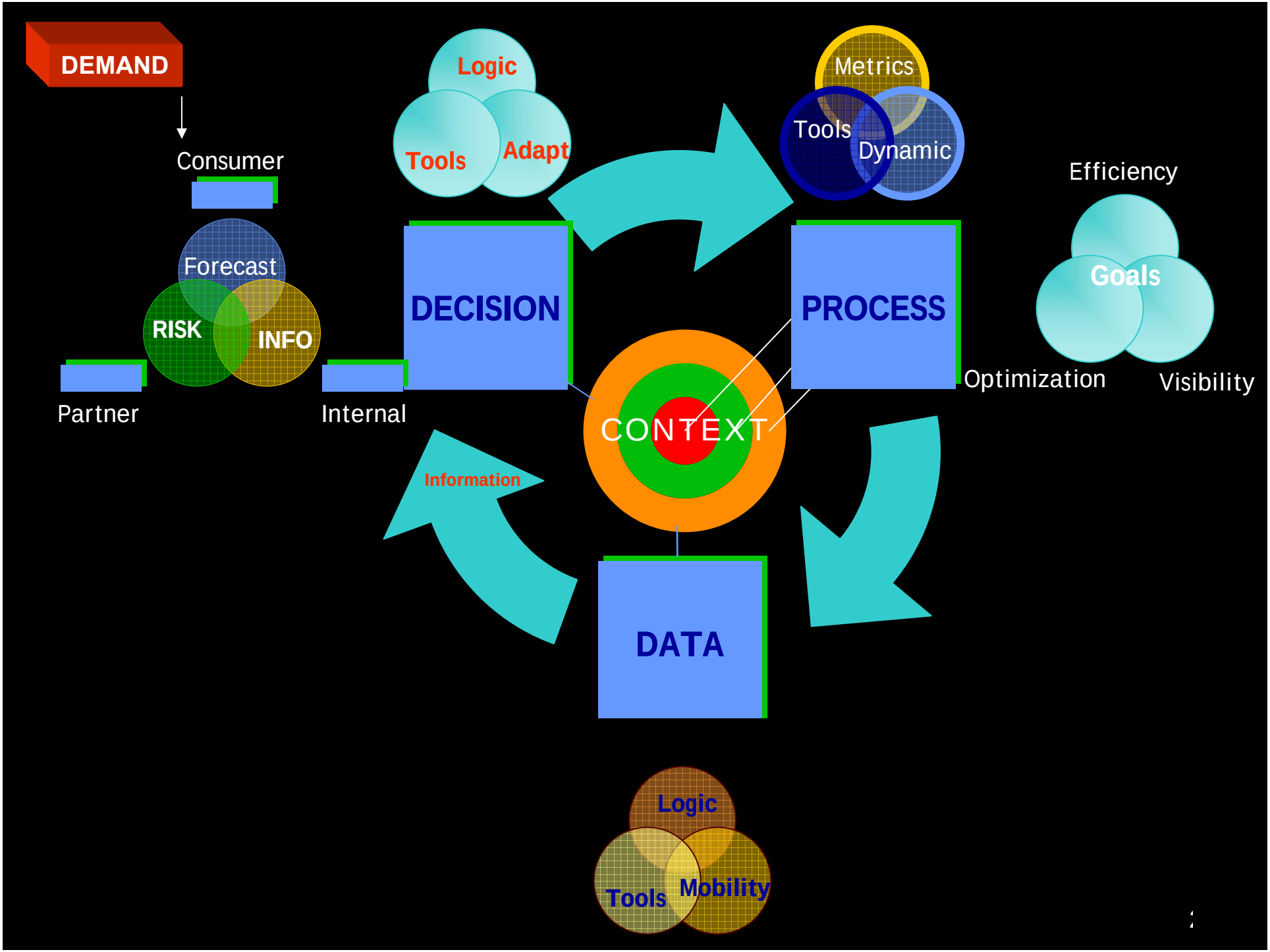
If ε_{1t} changes, it will change y_{1t} and y_{2t} since y_{1t} appears as one of the regressors (explanatory variable) for y_{2t} **(thus, volatility or uncertainty of 1 error term impacts all dependent variables). This impact was completely ignored thus far in all models, tools and forecasts.**



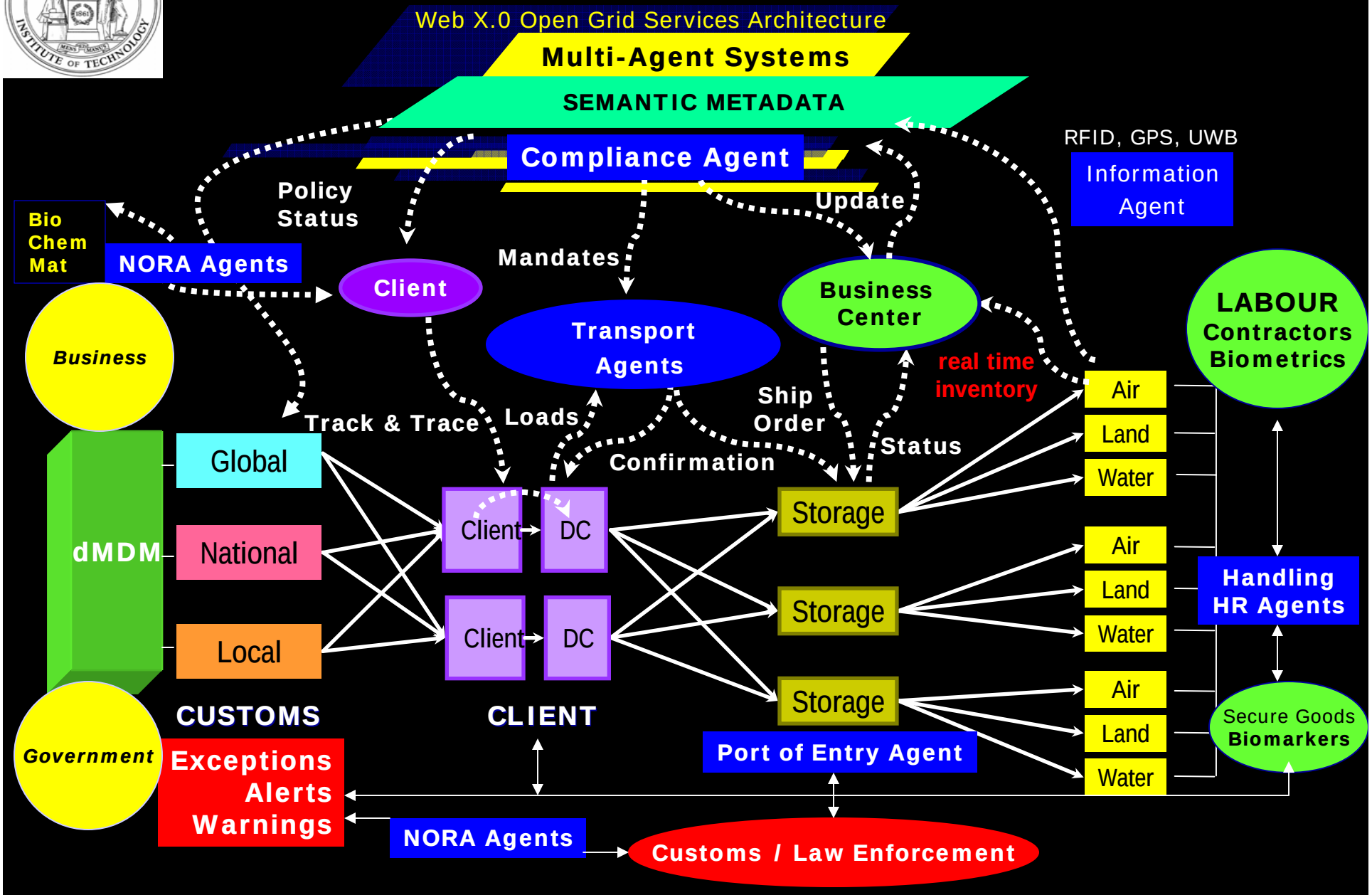
VAR-GARCH (+ ABM) : Real World Behaviour

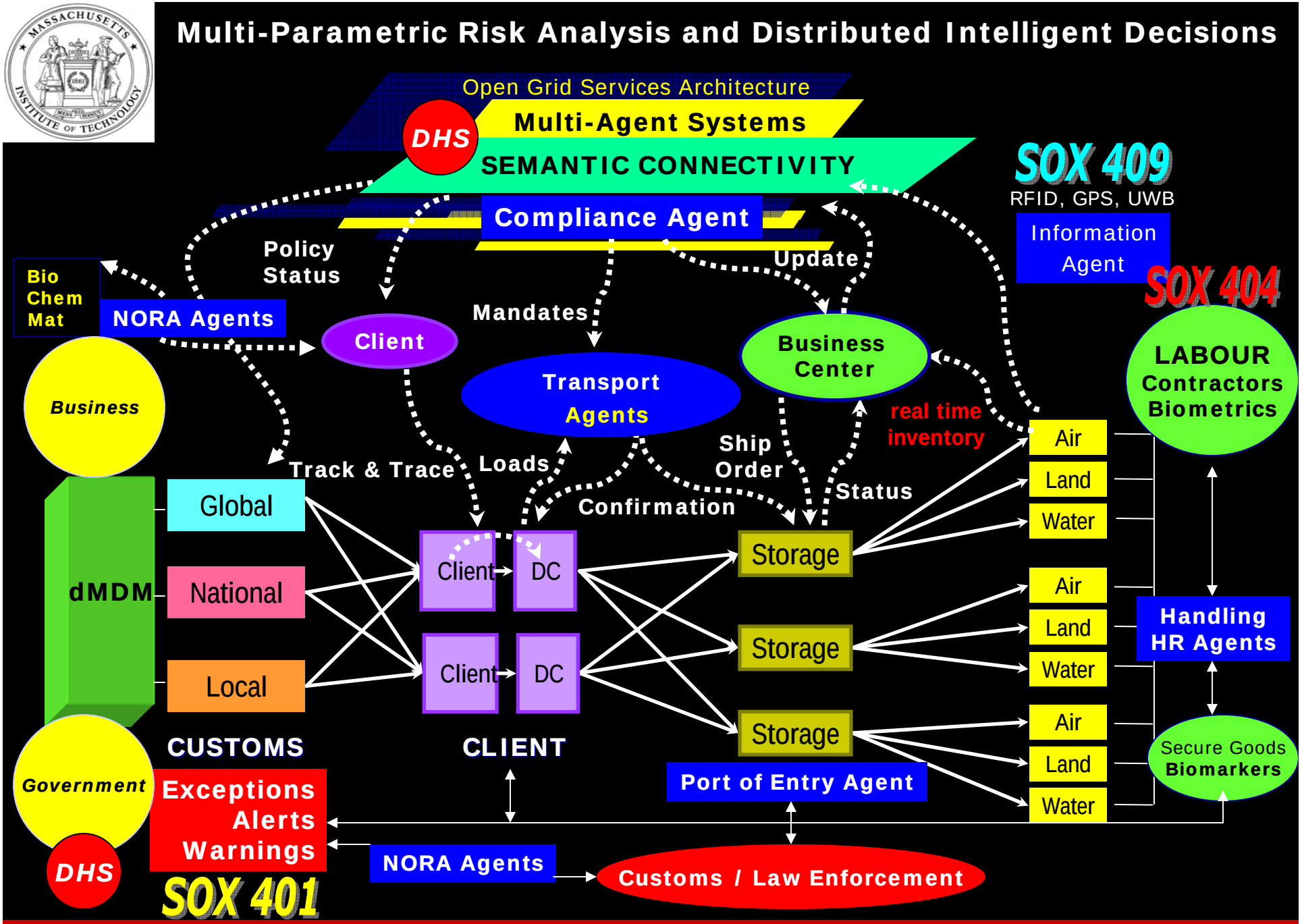
How can it DRIVE economic growth?

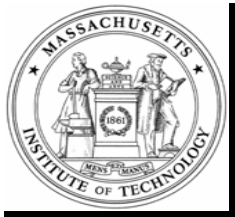
→ Systems Analytics (Software)


DEMAND
Consumer
Logic
Tools
Adapt
Metrics
Tools
Dynamic
Efficiency
Goals
Forecast
RISK
INFO
DECISION
PROCESS
Optimization
Visibility
Partner
Internal
CONTEXT
Information
DATA
Logic
Tools
Mobility

Transparent Interoperable Systems ? Information Lifecycle




Multi-Parametric Risk Analysis and Distributed Intelligent Decisions
Open Grid Services Architecture
DHS
Multi-Agent Systems
SEMANTIC CONNECTIVITY
SOX 409
RFID, GPS, UWB
Compliance Agent
Information Agent
Policy Status
Update
Bio Chem Mat
NORA Agents
Client
Mandates
Business Center
SOX 404
LABOUR Contractors Biometrics
Transport Agents
Business
real time inventory
Air
Land
Water
Track & Trace
Loads
Ship Order
Status
Confirmation
Global
National
Local
dMDM
Client
DC
Storage
Handling HR Agents
Secure Goods Biomarkers
CUSTOMS
CLIENT
Government
Exceptions Alerts Warnings
Port of Entry Agent
DHS
SOX 401
NORA Agents
Customs / Law Enforcement



End of the Information Age

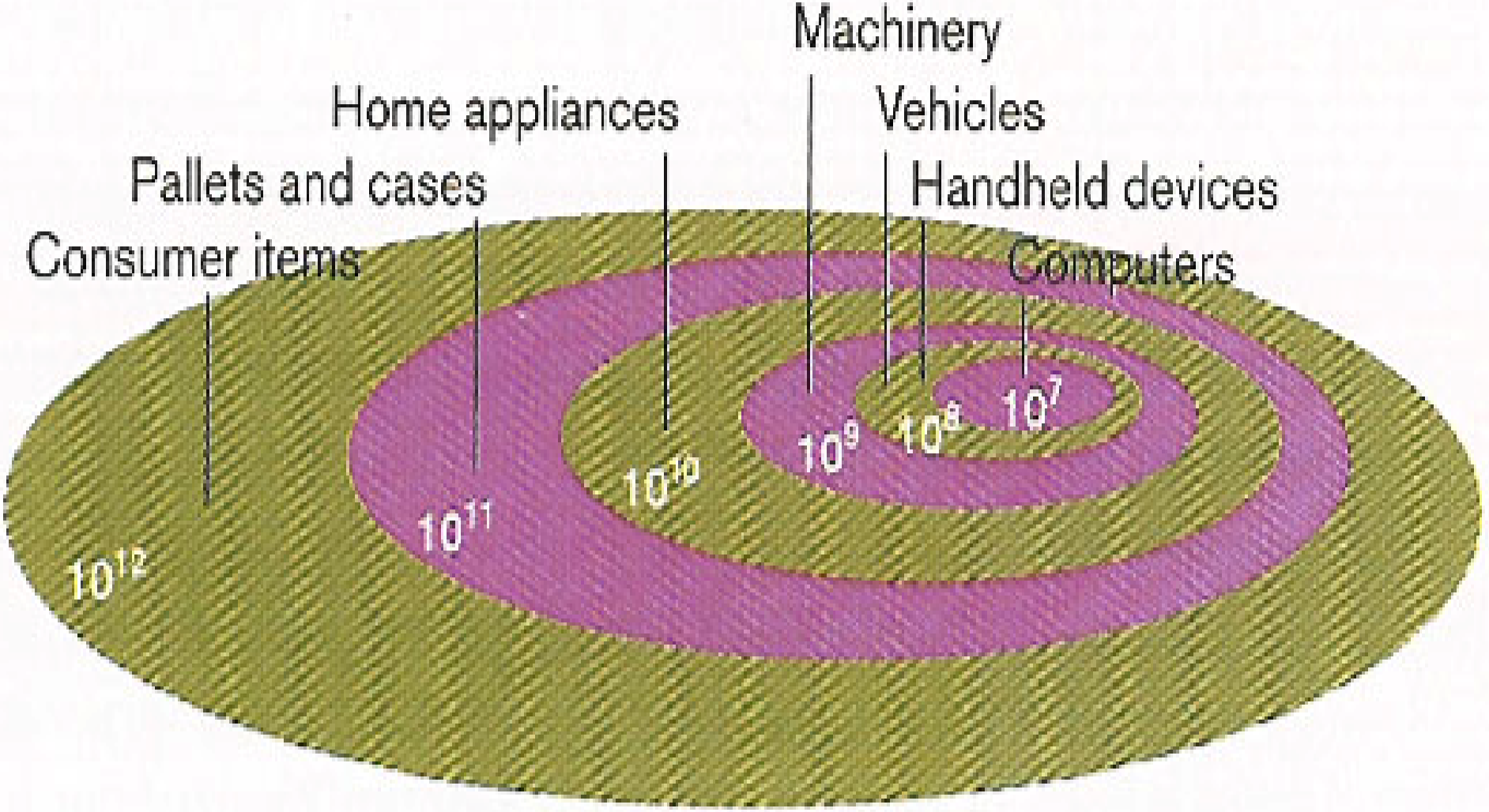
End of the Information Age

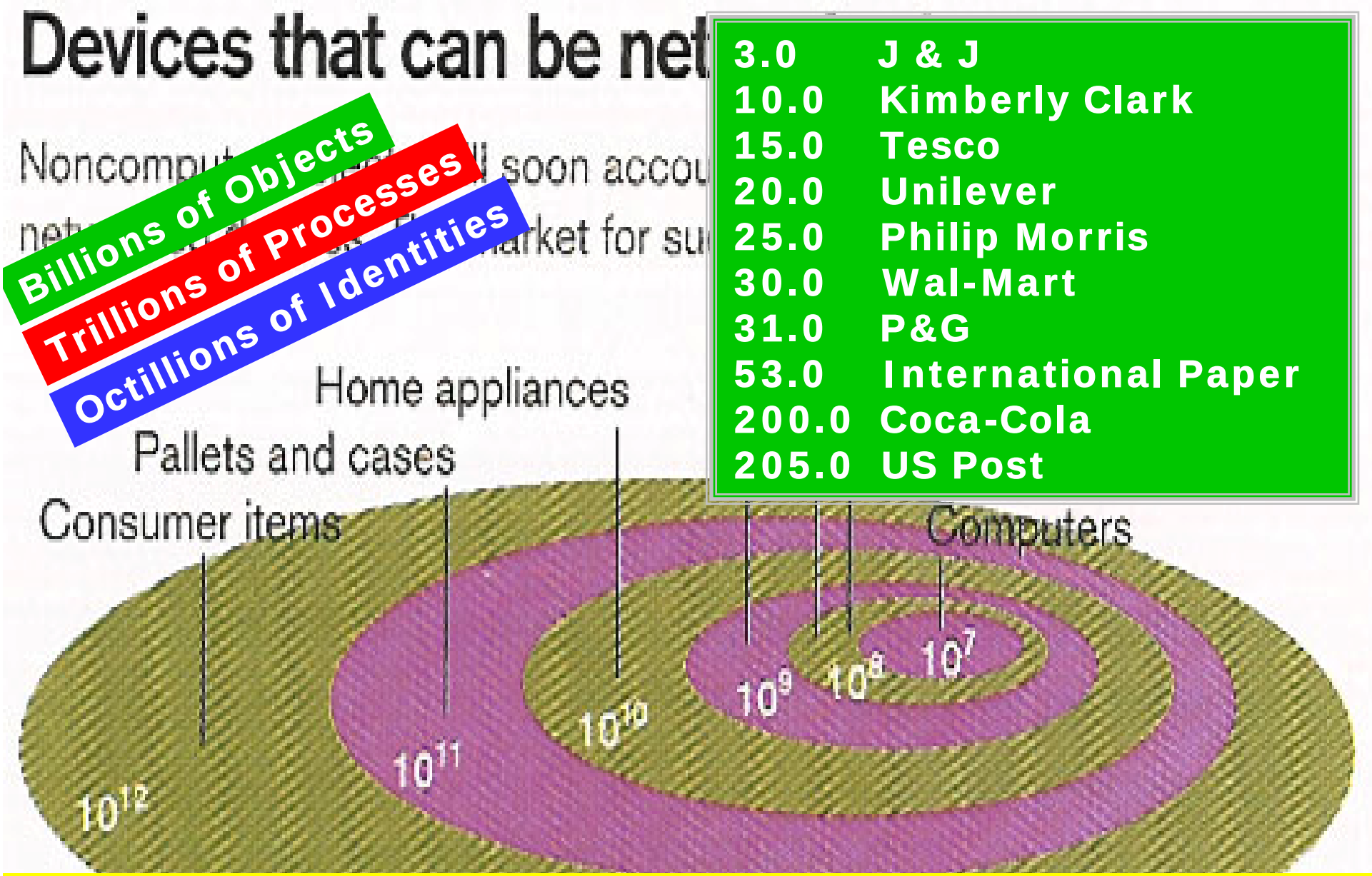
Welcome to the

SYSTEMS AGE

Devices that can be networked

Noncomputer objects will soon account for the vast majority of networked devices. The market for such things is enormous.

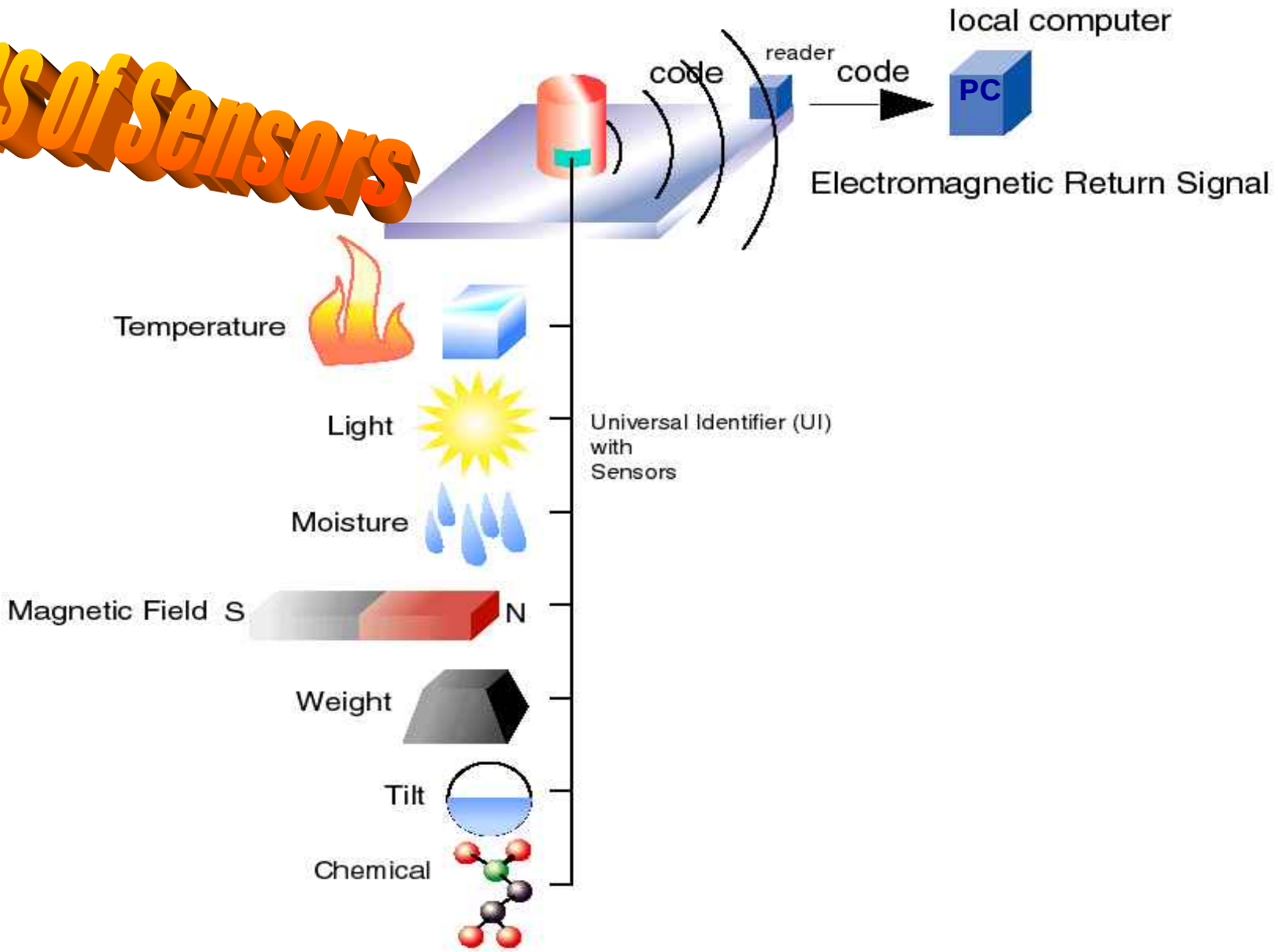




EPC 64-bit: 18,446,744,073,709,551,616 (1.8×10^{19})
EPC 96-bit: 79,228,162,514,264,337,593,543,950,336 (7.9×10^{28})
Objects with RFID tags possess id; excludes “process” information

Data

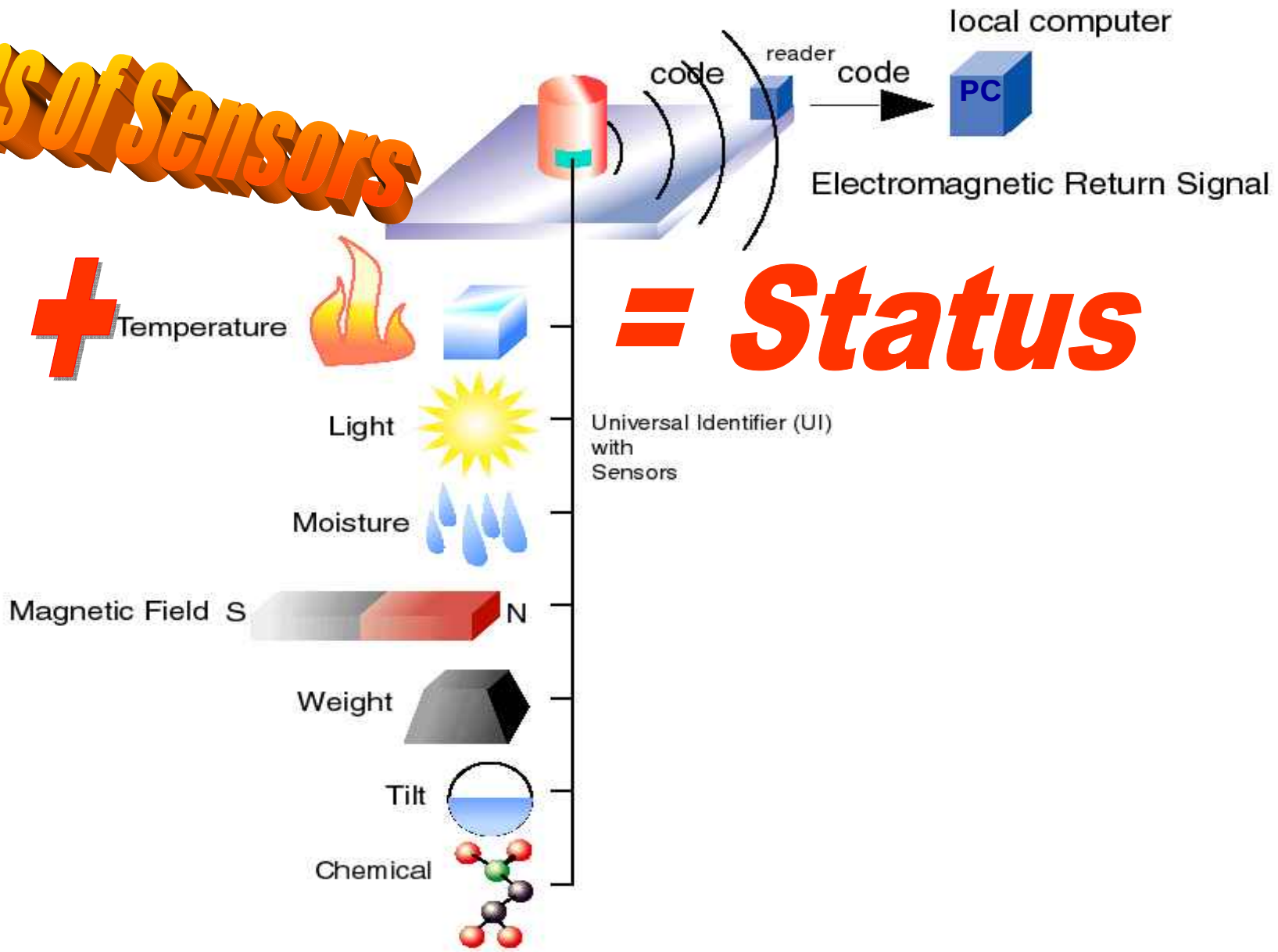
Trillions of Sensors



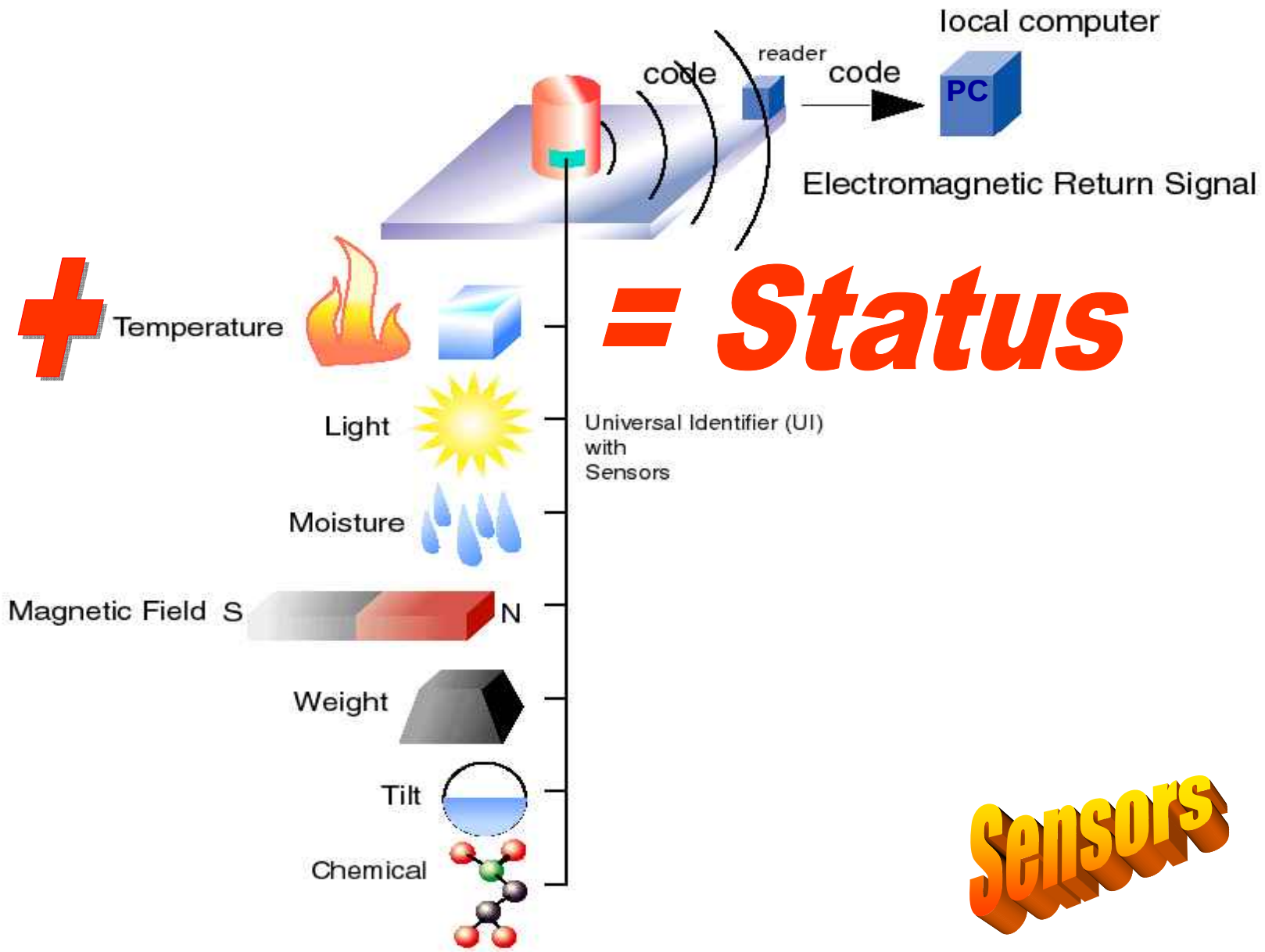
Process, Data, Information

Trillions of Sensors

ID + = Status



Data is not Information



ID + = Status

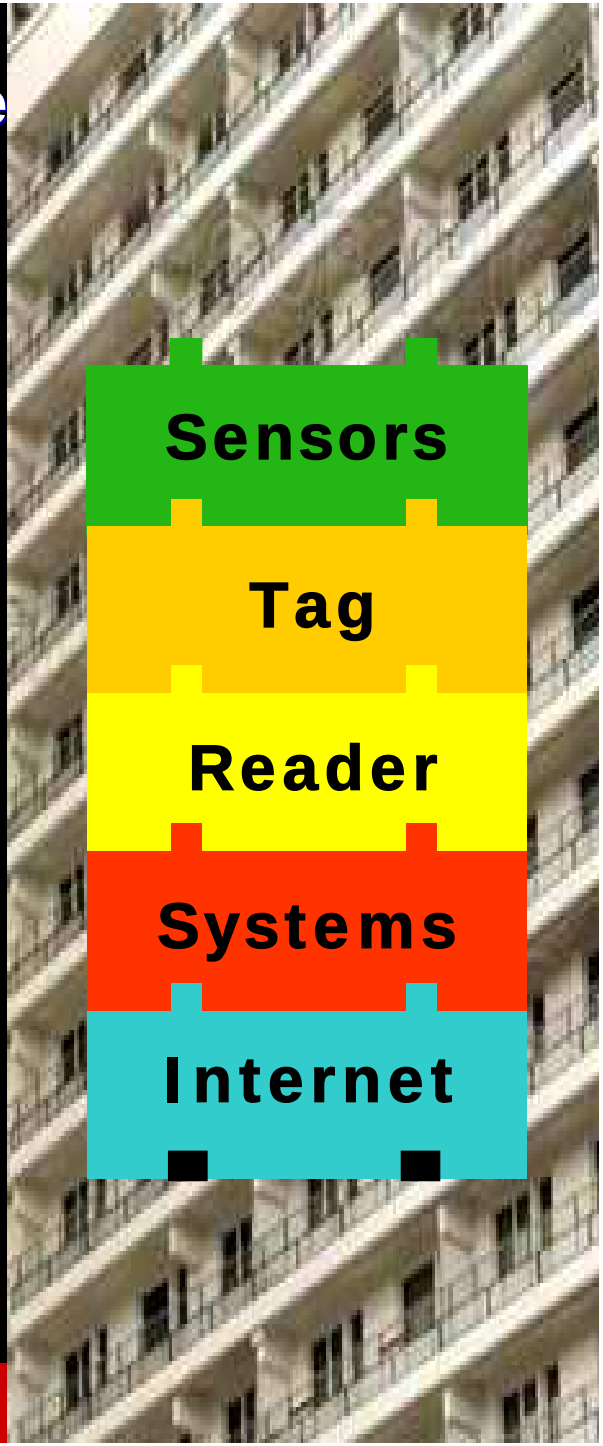
Sensors

Customs: Information Arbitrage

The Systems Age

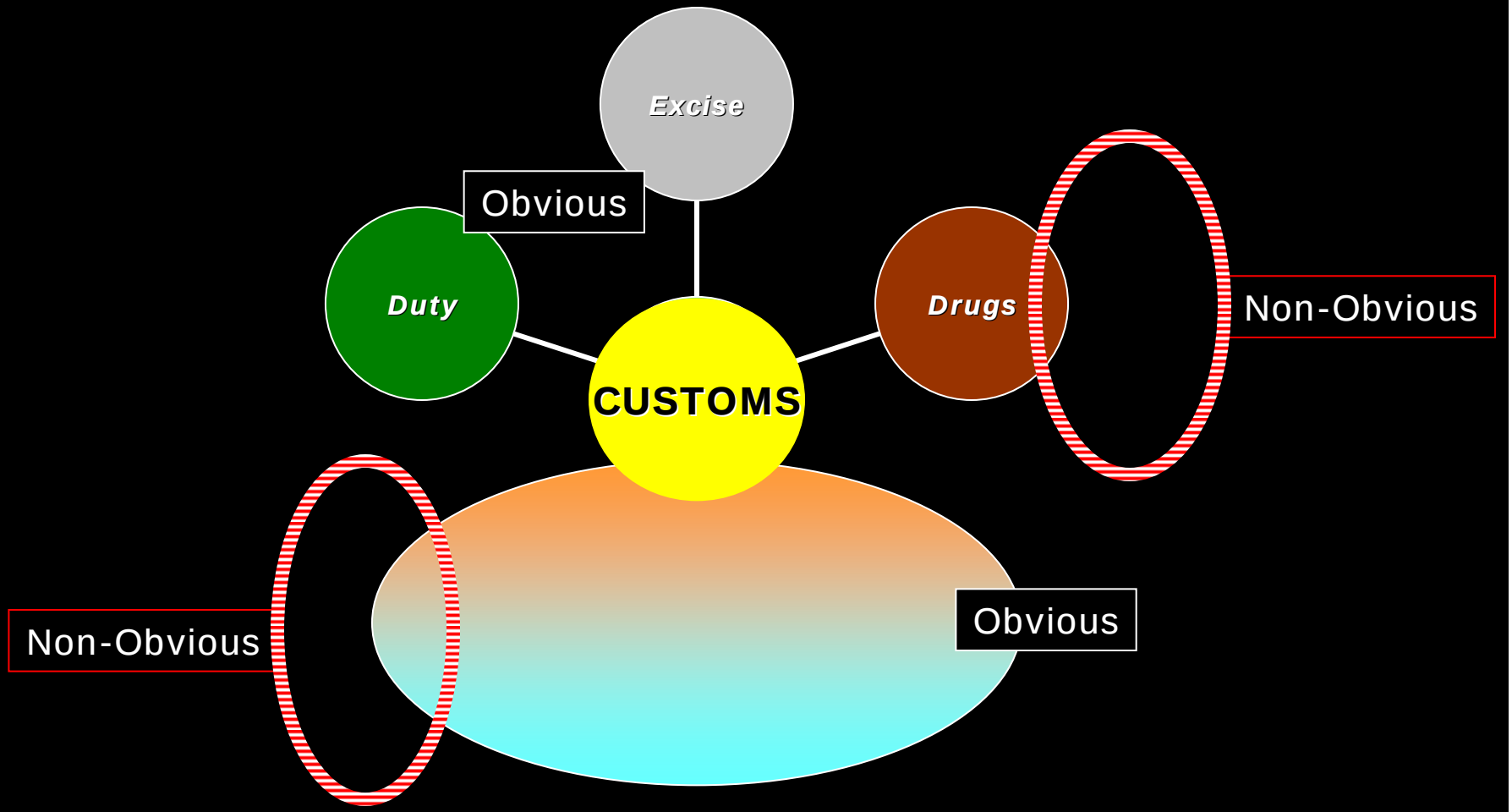
The World Is Not Flat

- Interoperability
- Transparency
- Collaboration
- Adaptability
- Identity



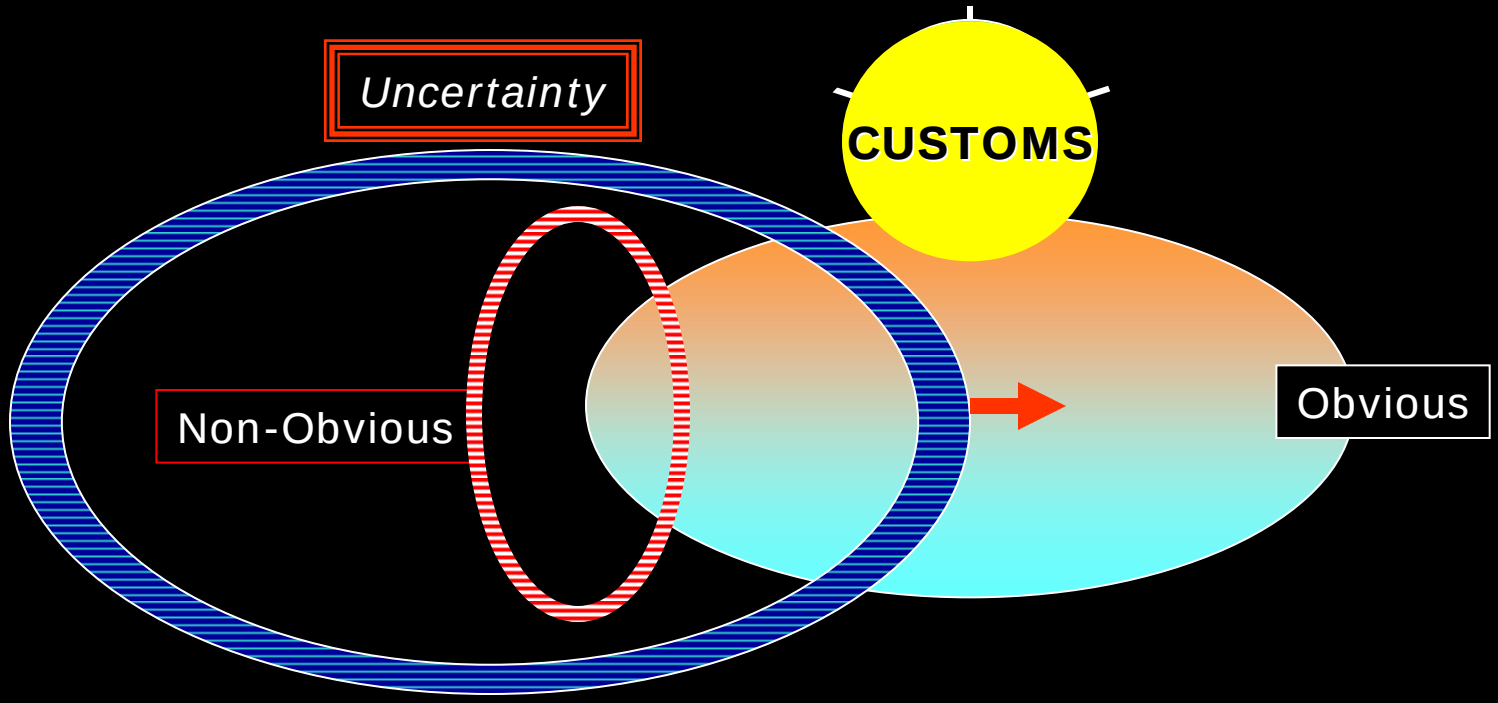
Dr Shoumen Palit Austin Datta < shoumen@mit.edu > MIT Forum for Supply Chain Innovation

Obvious vs Non-Obvious Relationship Analysis



Uncertainty fuels demand for Risk Simulation

Assigning the correct degree of fear to distant elephants!

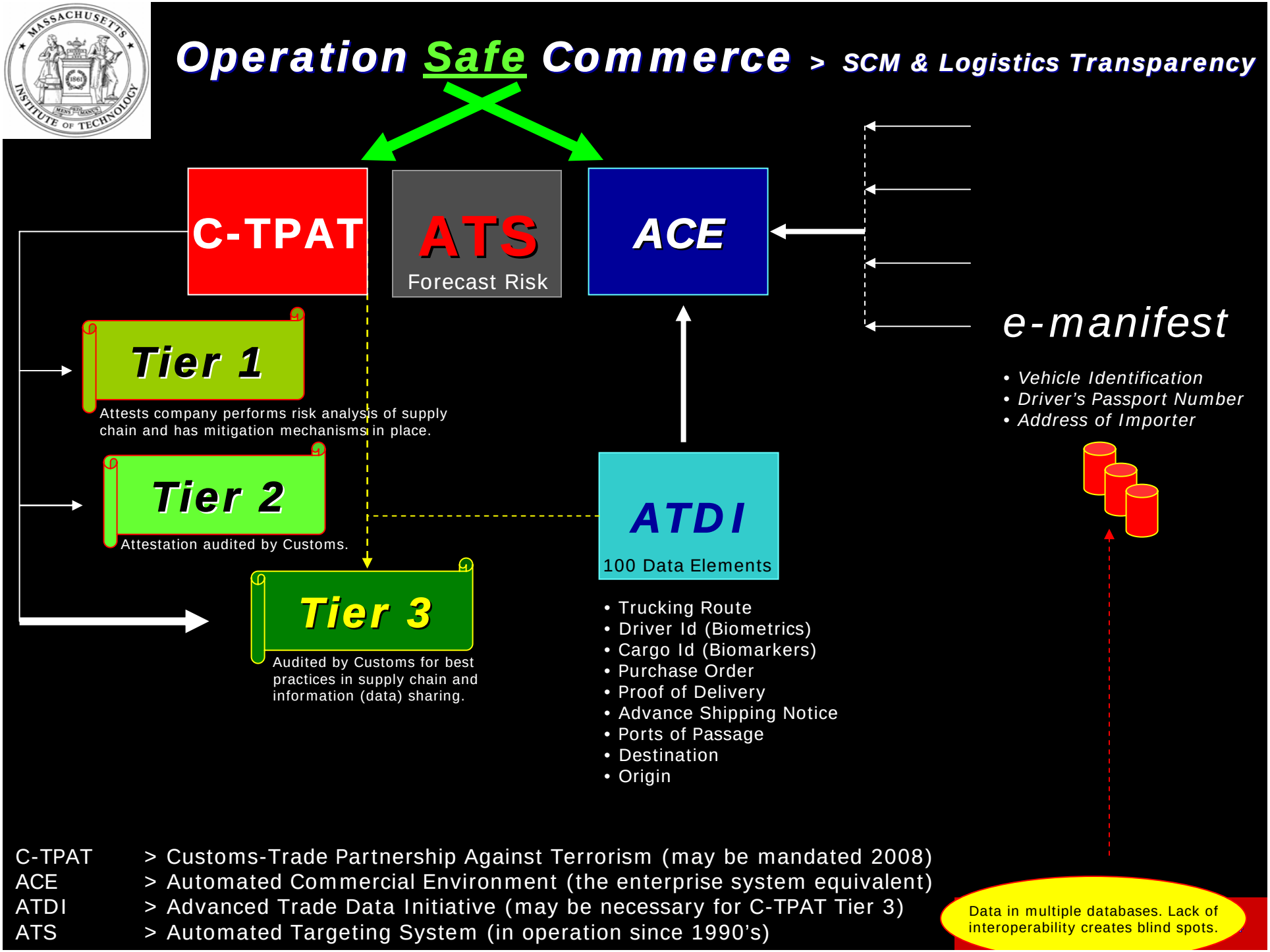


Customs – Security Risk
Business – Supply Chain Risk

Operation Safe Commerce: Answers, not Numbers

Goal:	Identify Weak Links in Supply Chain
Scope:	Use GPS-RFID track & trace from overseas origin to US destinations
Users:	Included Sara Lee and Motorola
Duration:	2002-2005
Ports:	SEA-TAC, LA, NY-NJ
Cost :	$75 million
Report:	Due 2005 February
Published:	None Released
Rumour:	Companies know very little about their supply chain

Operation Safe Commerce > SCM & Logistics Transparency



C-TPAT > Customs-Trade Partnership Against Terrorism (may be mandated 2008)
ACE > Automated Commercial Environment (the enterprise system equivalent)
ATDI > Advanced Trade Data Initiative (may be necessary for C-TPAT Tier 3)
ATS > Automated Targeting System (in operation since 1990's)

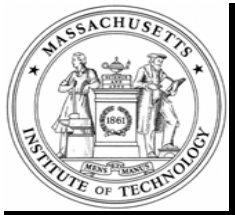
Data in multiple databases. Lack of interoperability creates blind spots.

Global Security Risk: System of Systems

Section 401 of the Sarbanes-Oxley Act (SOX) require companies to account for risk in off-balance-sheet transactions, supply chains. Companies need to have controls to protect against adverse events in their supply chains.

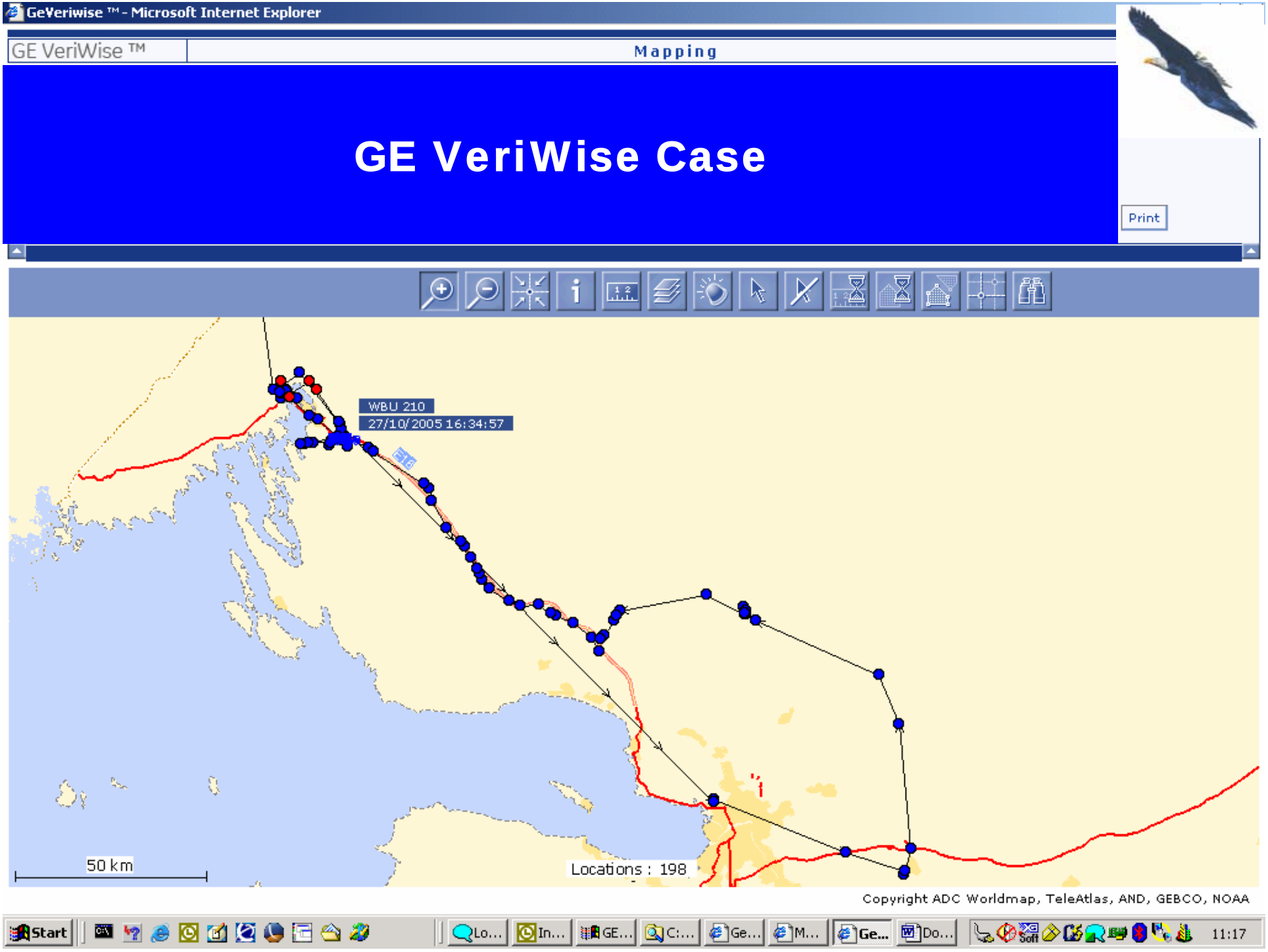
Section 404 of Sarbanes-Oxley (SOX) require companies to establish controls that provide reasonable protection against preventable events that may impact a company's value. **Labour personnel links to organized crime.**

Section 409 of the Sarbanes-Oxley Act (SOX) require reports 'on a rapid and current basis' events that could have some material impact. Near-real time track and trace data or status.



RISK ASSESSMENT THREAT

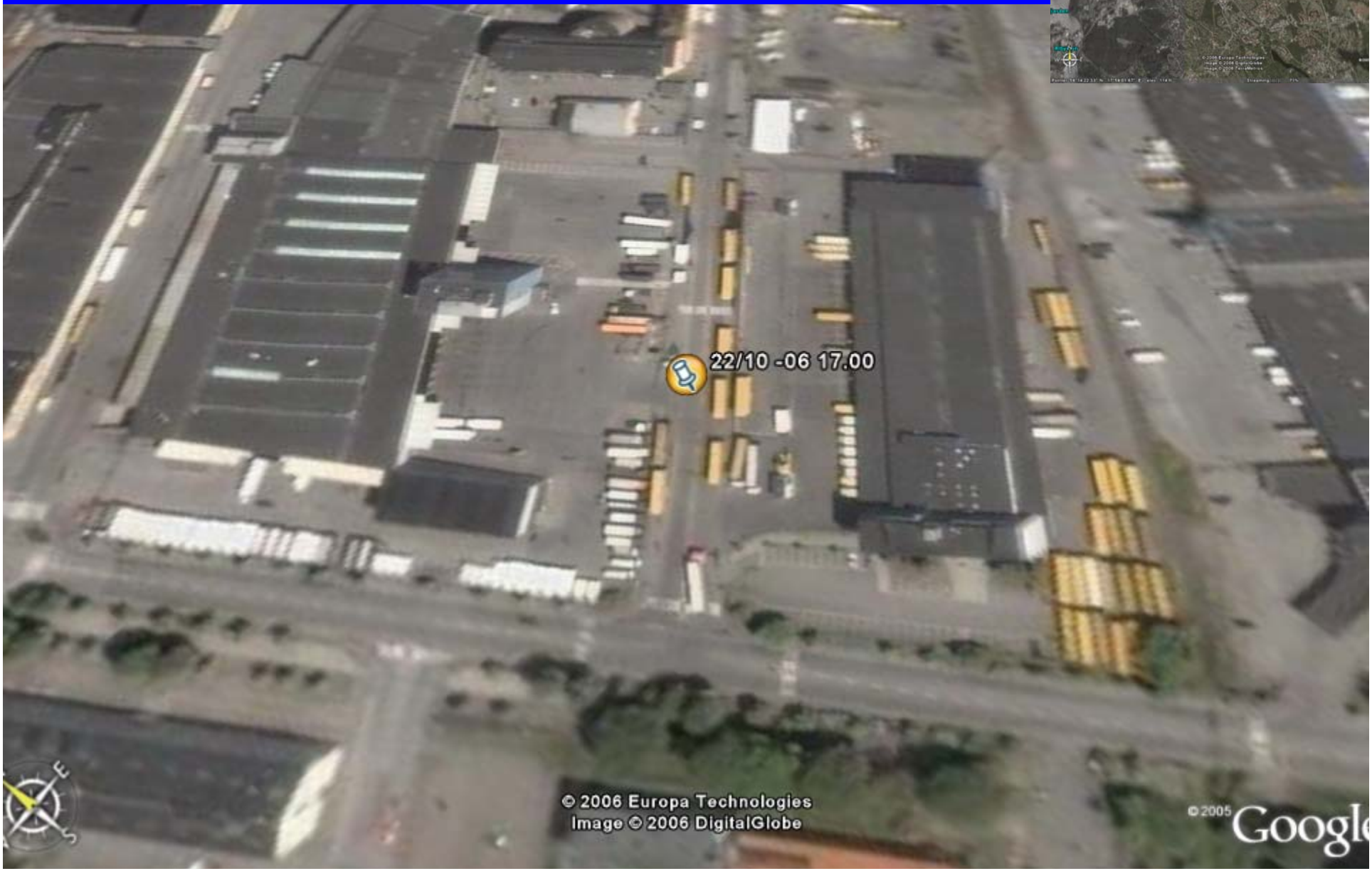
- 3.9 million miles of public roads
- 600,000 bridges
- 1.2 million trucking companies
- 15.5 million trucks
- 42,000 hazardous material (HAZMAT) trucks
- 10 million commercial vehicle drivers
- 2.7 million HAZMAT drivers
- 2.2 million miles of hazardous liquid & gas pipeline
- 120,000 miles of major railroads
- 500,000 train stations
- 15 million daily riders on mass transit
- 25,000 miles of commercial waterways
- 361 ports
- 250,000 containers per day
- 9.0 million containers through 51,000 port calls
- 11.2 million containers via Canada and Mexico
- 19,576 public airports, heliports and landing strips
- 459 Federalized commercial airports
- 211,450 general aviation aircraft
- 77% of all flights are general aviation


GeVeriwise ™ - Microsoft Internet Explorer
GE VeriWise ™
Mapping
GE VeriWise Case
Print
WBU 210
27/10/2005 16:34:57
50 km
Locations : 198
Copyright ADC Worldmap, TeleAtlas, AND, GEBCO, NOAA
Start
11:17

Stockholm

22 Oct 2006

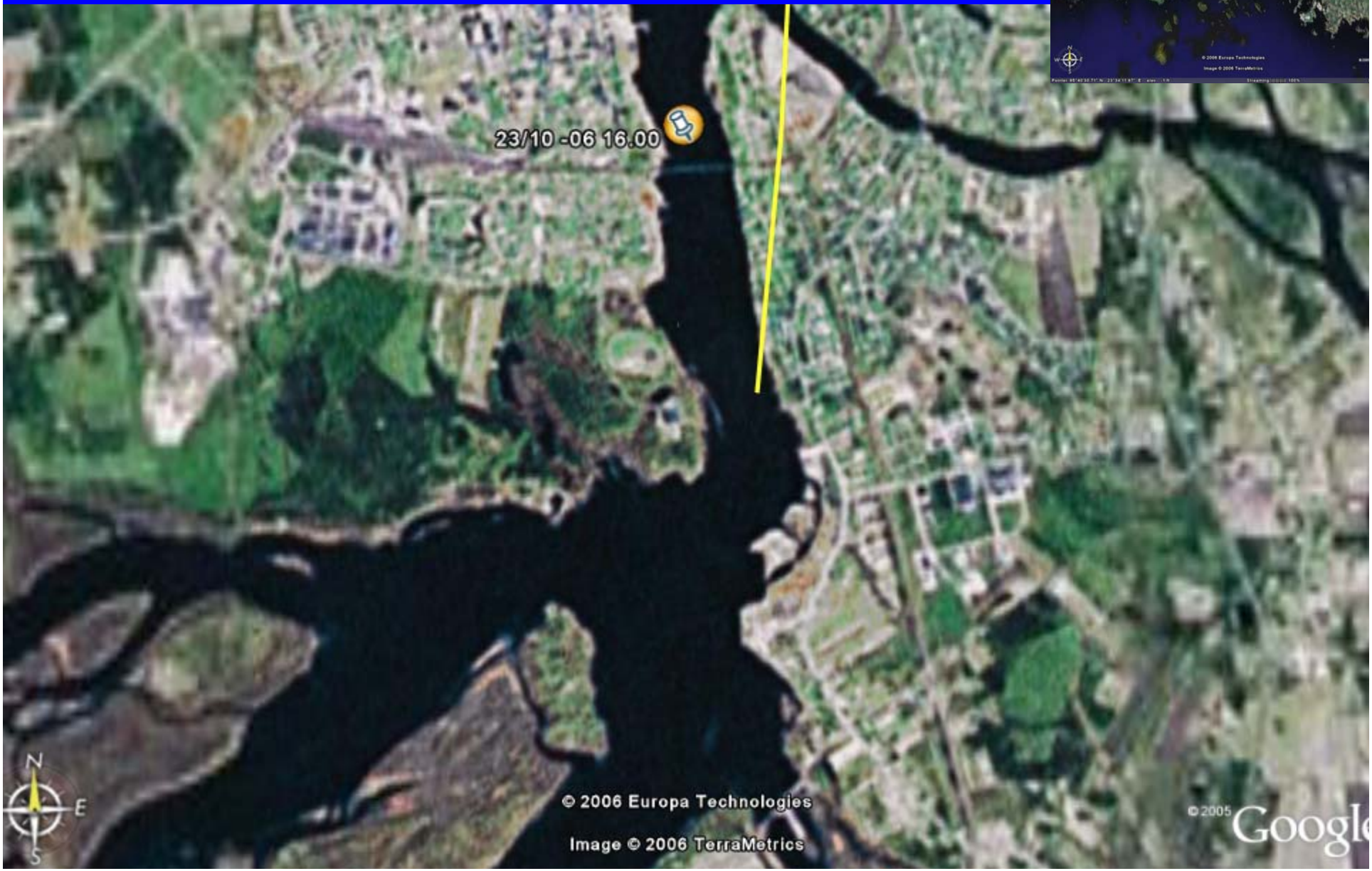
1700 hours



Border: Sweden-Finland

23 Oct 2006

1600 hours



Border: Finland-Russia

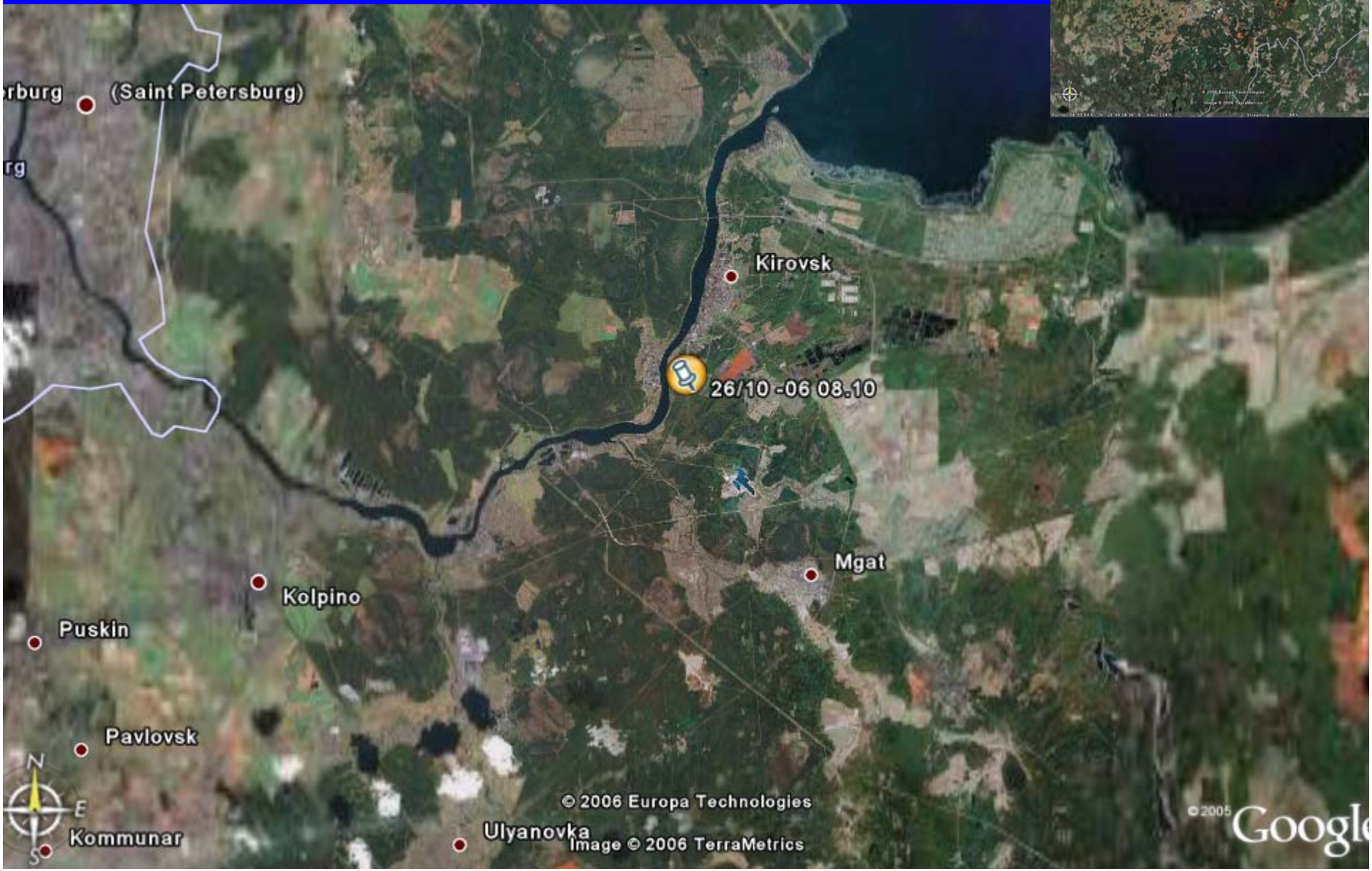
24 Oct 2006

1400 hours

30km East of St Petersburg, Russia

26 Oct 2006

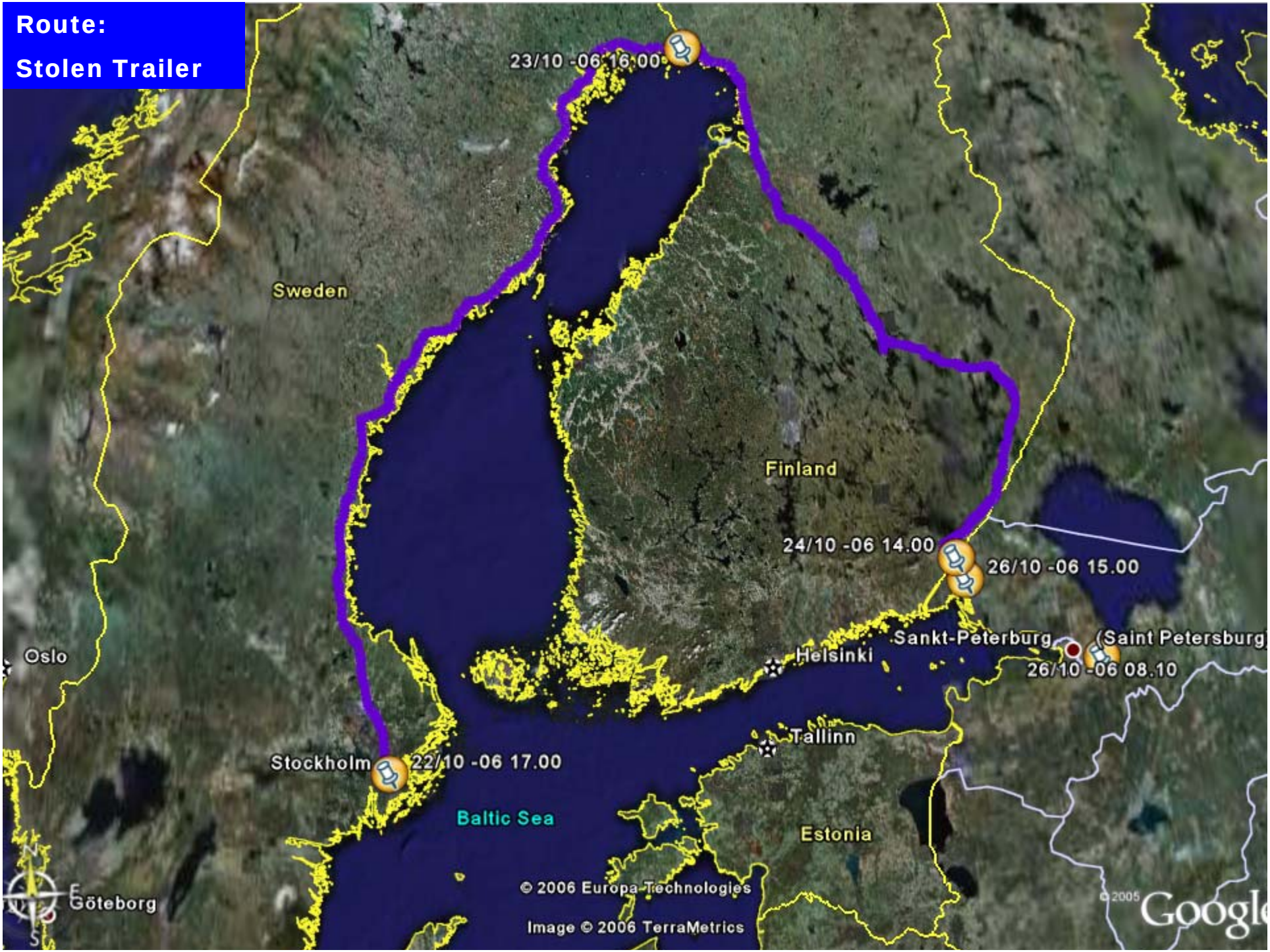
0810 hours

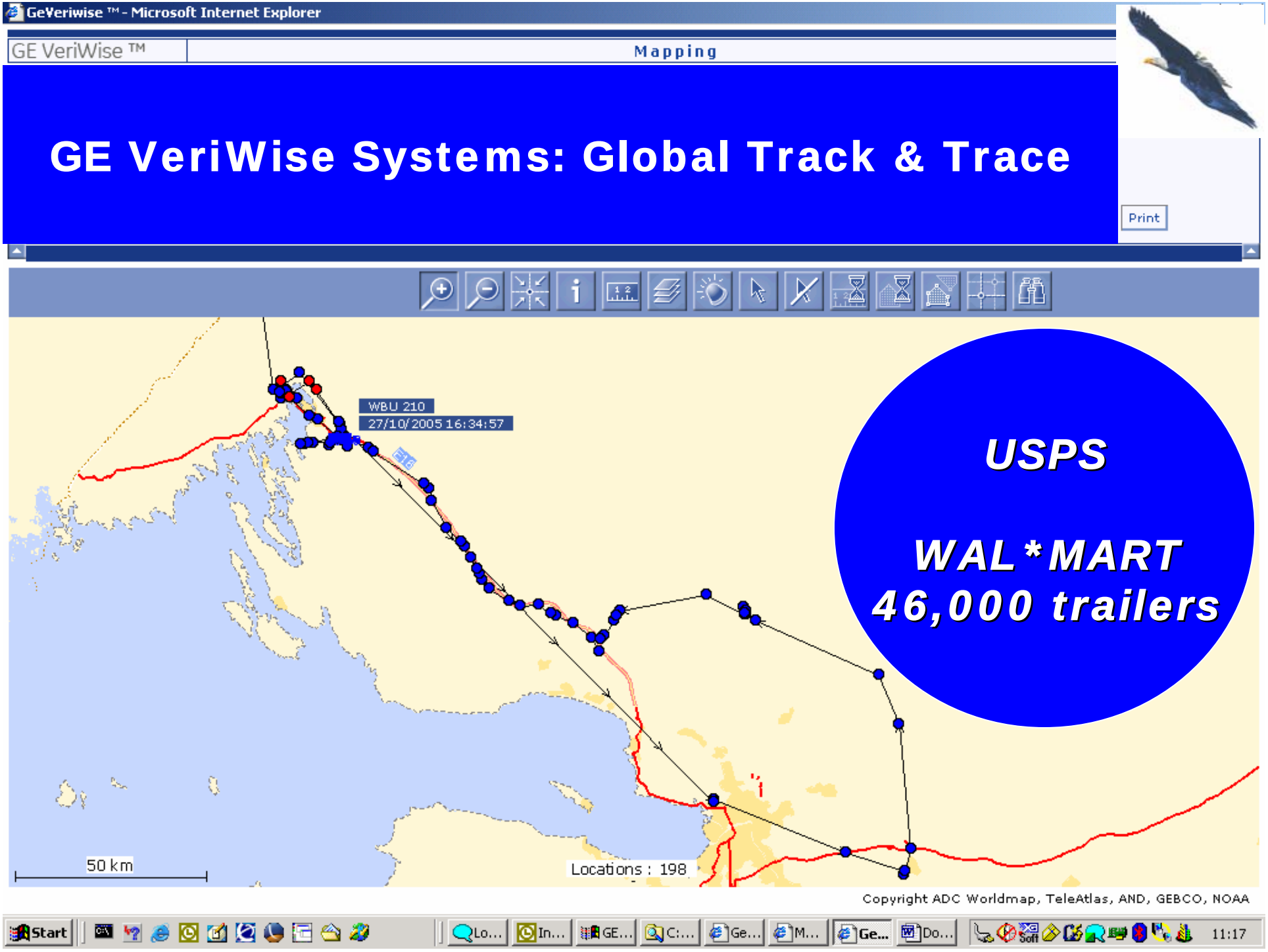


Vyborg

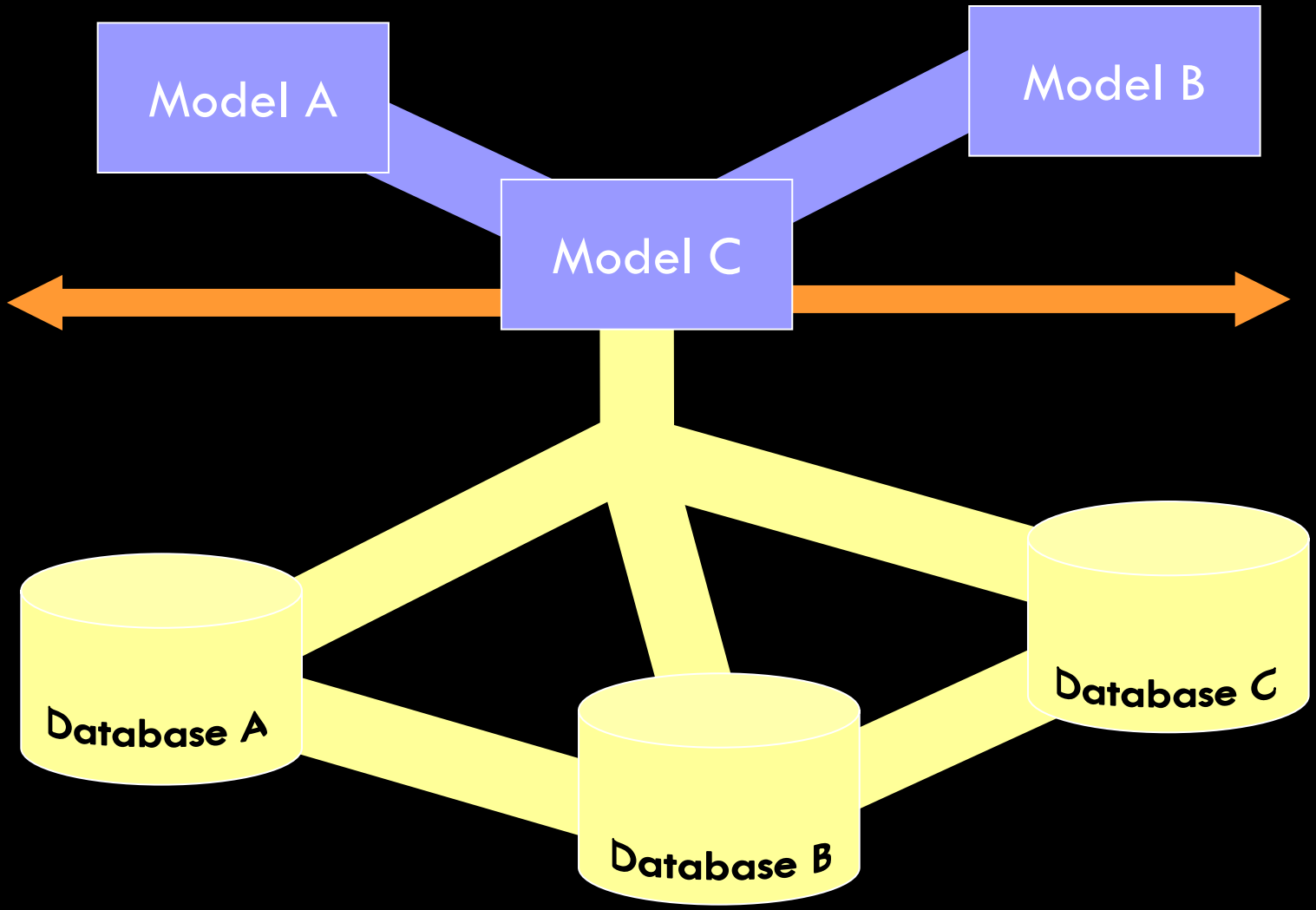
26 Oct 2006

1500 hours

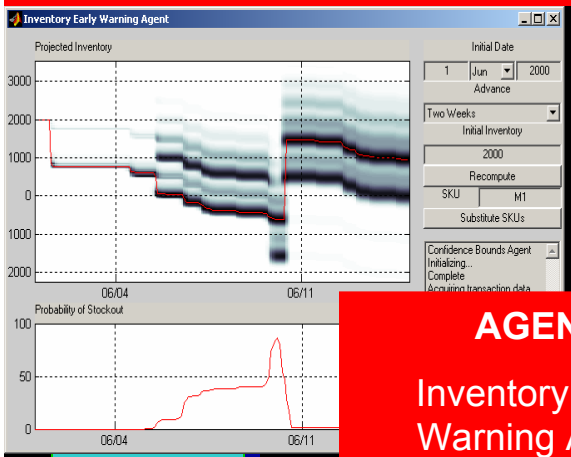

Route:
Stolen Trailer
23/10 -06 16.00
Sweden
Finland
24/10 -06 14.00
26/10 -06 15.00
Sankt-Peterburg
(Saint Petersburg)
26/10 -06 08.10
Helsinki
Oslo
Tallinn
Stockholm
22/10 -06 17.00
Baltic Sea
Estonia
Göteborg
© 2006 Europa Technologies
Image © 2006 TerraMetrics
©2005
Google


GeVeriwise ™ - Microsoft Internet Explorer
GE VeriWise ™
Mapping
GE VeriWise Systems: Global Track & Trace
Print
WBU 210
27/10/2005 16:34:57
USPS
WAL*MART
46,000 trailers
50 km
Locations : 198
Copyright ADC Worldmap, TeleAtlas, AND, GEBCO, NOAA
Start
11:17

System of Systems: Network Integration and Interoperability



Smart Planning with Intelligent Objects



ACTION

REPLENISHMENT

AGENT

Inventory Early Warning Agent

X days ?

Store 1

Store 2

Store 3

Store n

RETAILER

Plant

2 days

Distribution Center

3 days

Distribution Center

MANUFACTURER

EVENT

Y days ?

AGENT

Information Agent

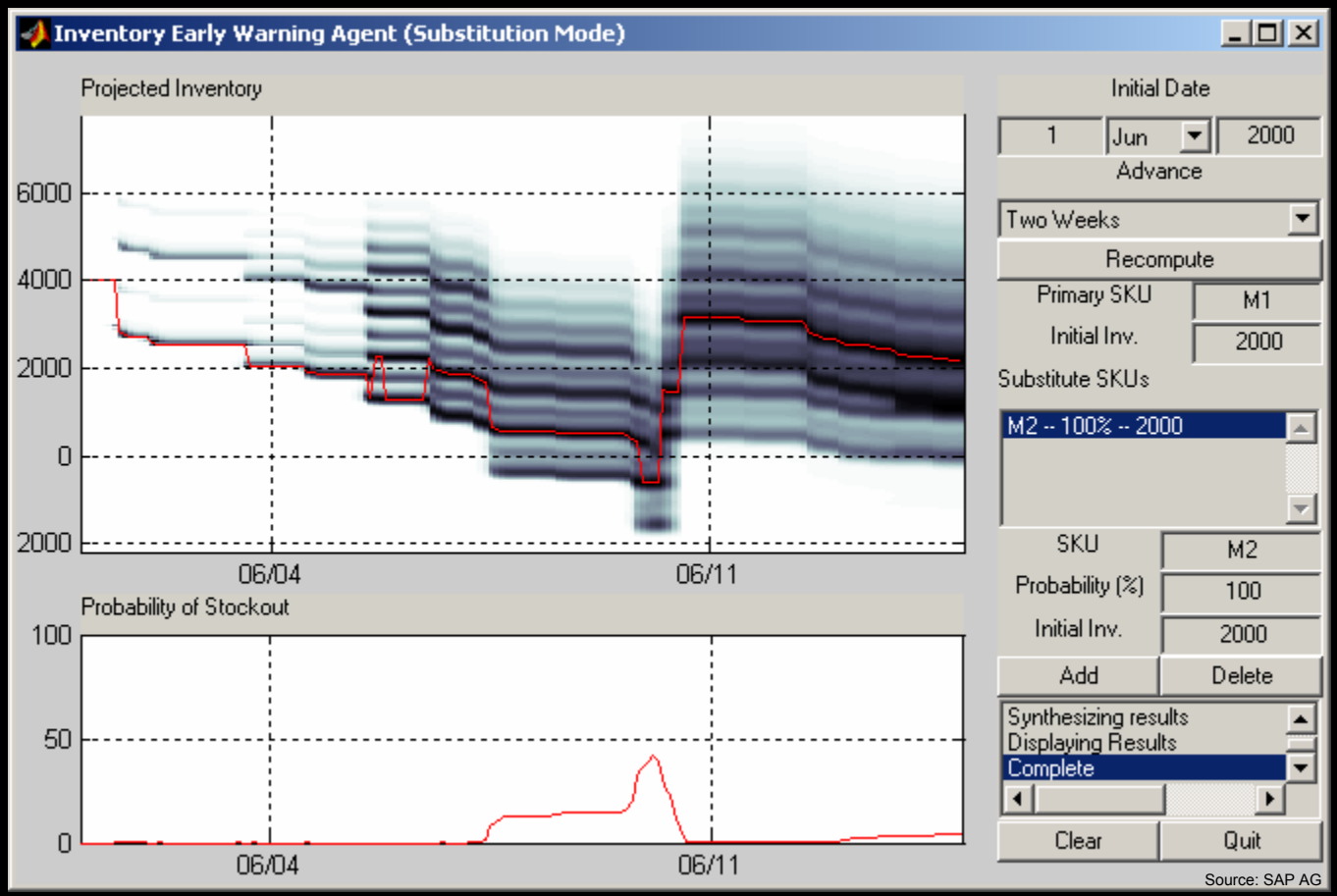
RFID Data

Inventory

Consumption

Multi-Agent System

Data Agents collect ► Data
Monitoring Agent triggers ► Alert
Inventory Management Agent executes ► Substitution

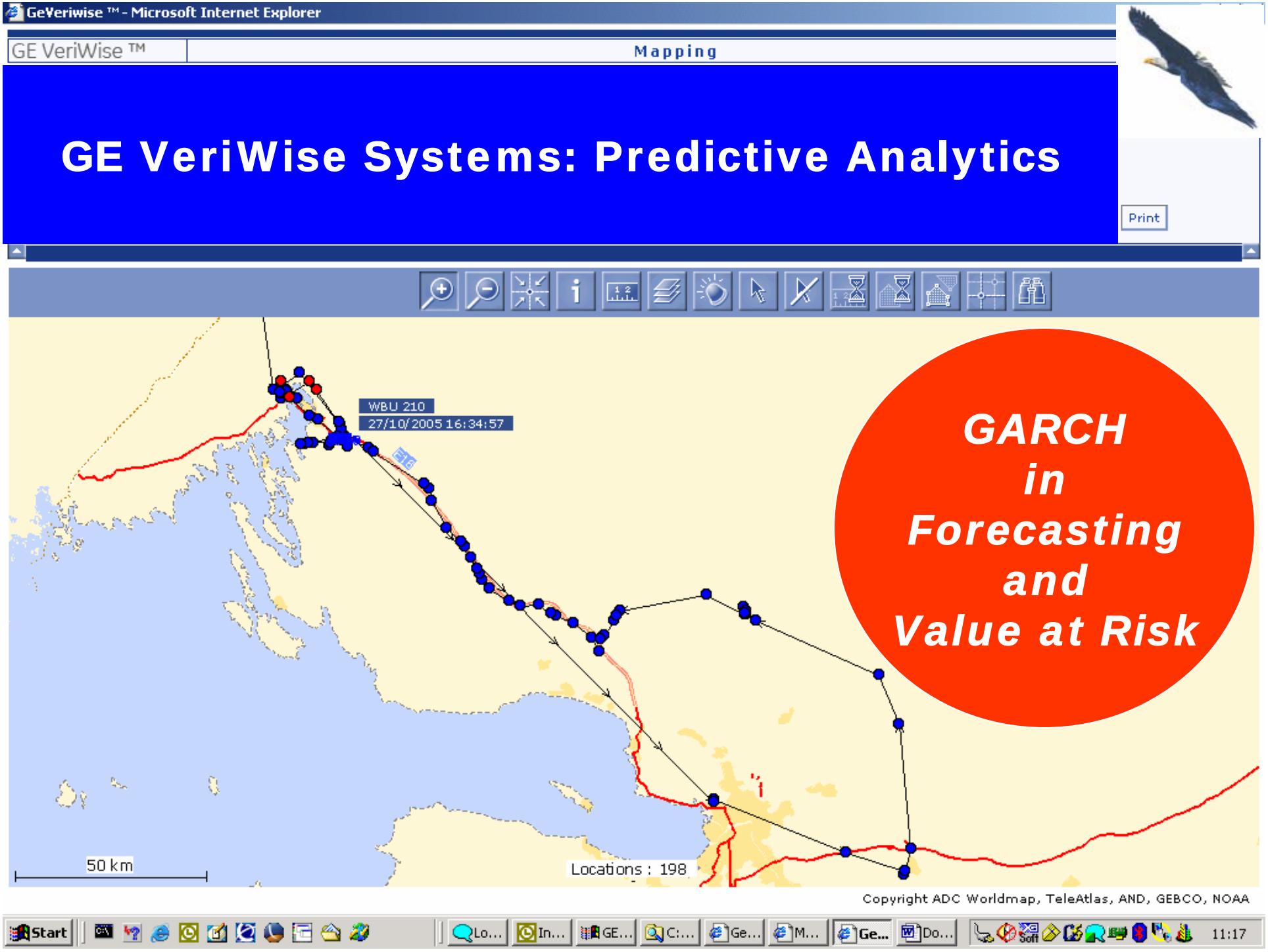


M2 can be substituted for SKU M1

Inventory of M2 is 2000

OOS Danger

Less chance of a stockout with substitution via agent actions (M1 & M2)


GeVeriwise ™ - Microsoft Internet Explorer
GE VeriWise ™
Mapping
GE VeriWise Systems: Predictive Analytics
Print
WBU 210
27/10/2005 16:34:57
GARCH
in
Forecasting
and
Value at Risk
50 km
Locations : 198
Copyright ADC Worldmap, TeleAtlas, AND, GEBCO, NOAA
Start
11:17

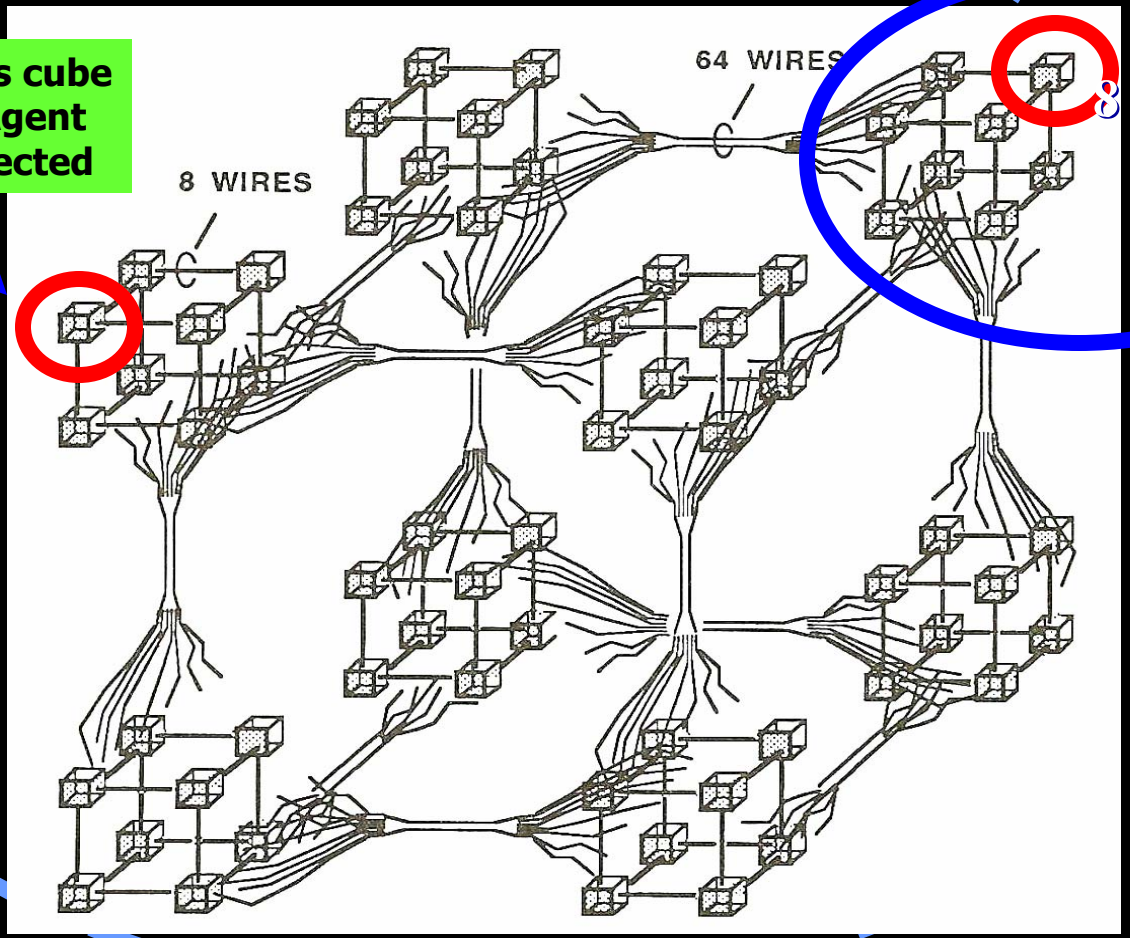
'Wiki City Rome' at MIT obtains data anonymously from phones and devices to map Rome in real time

Data → Information

8 corners of larger cube
8 Agents repeated 8 times

64

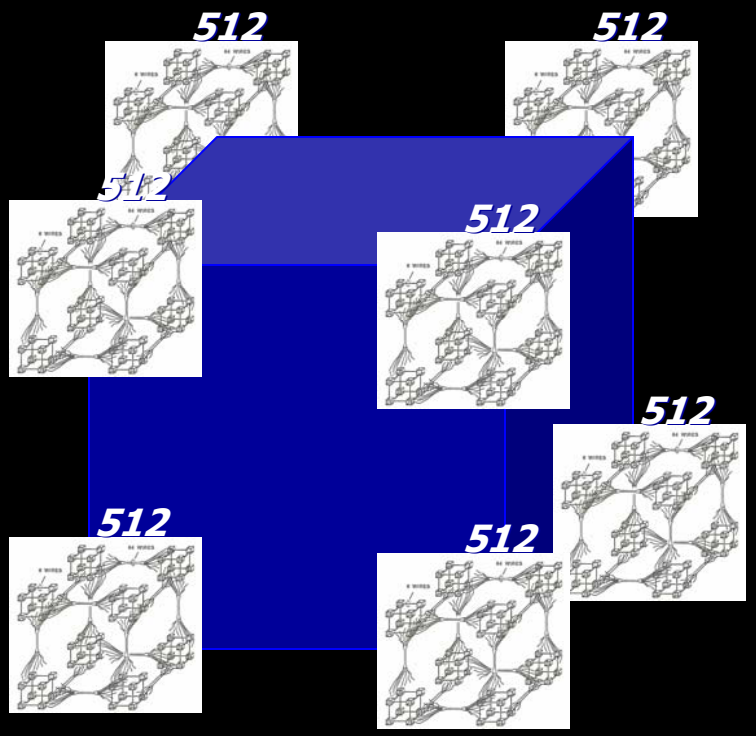
8 corners of this cube
1 corner = 1 Agent
8 Agents connected



= 512

Society of Mind by Marvin Minsky

Data Cube



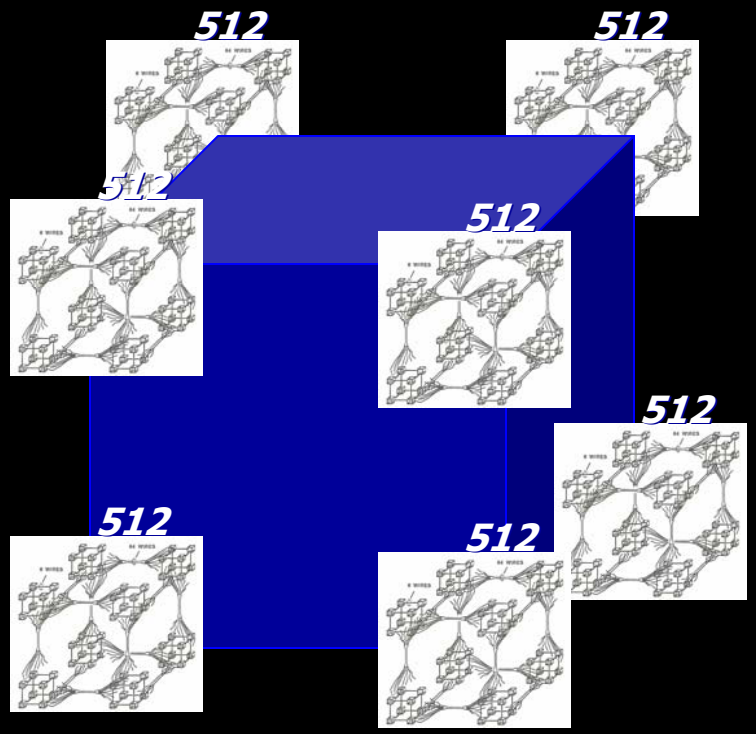
Organize information
-collection of independent variables
-Relationship analysis

Large Hadron Collider (2007)
800 million collisions/second (12 DVD/min)
- Courses and trajectory changes
- Energies of particles involved in collisions
- Where and when

Metereology – climate models
Epidemiology – spread of infection (H5N1)

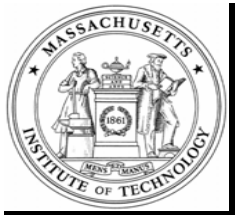
Cube-on-Cube: Step 4

Cube-on-Cube: Step 4



Agents interconnected

8 X 512 = 4096



Cube-on-Cube: Step 10

Cube-on-Cube: Step 10

Repeat this cube-on-cube pattern 10 times (10 steps).

Supercube (8^{10} = 1, 073,741,824) will contain over 1 billion Agents.

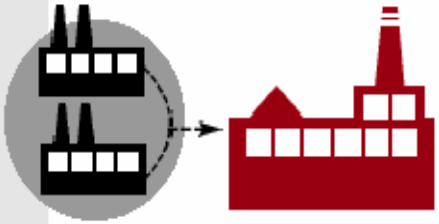
Each Agent in the original smallest cube (of 8 Agents) can communicate with 1 billion Agents (sources, variables) in 10 steps.

Link each Agent to 50 other Agents:
Each Agent communicates with >15 billion Agents in 6 steps (50^6).

CocaCola can monitor nearly *each RFID tagged unit case* of its product. Real-time data can be collected by an Agent (Agency) in mere 6 steps for analysis (inventory, distribution, storage, transit, temperature). In 2004, CocaCola produced 19.8 billion unit cases.

P&G's Agent-Enabled Supply Network in 2008

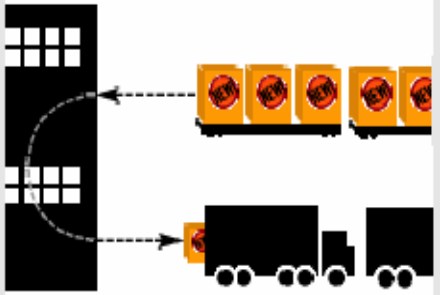
By 2008, P&G will have shortened the end-to-end replenishment cycle for a box of Tide from four months to one day. Here's how:



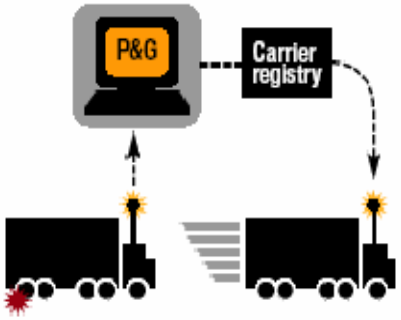
1 It's 2008, and P&G has replaced its numerous specialized plants with a few "flexi-plants" – highly versatile facilities with quick turnaround capabilities

2 Software agents of a key supplier detect a looming hurricane that threatens a Puerto Rico operation. They alert P&G's software agents and work with them to create an alternative delivery schedule so P&G's Miami plant doesn't face a material shortage.

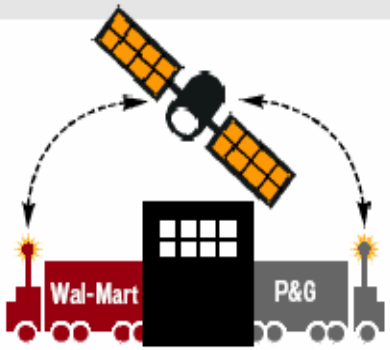
3 The Miami facility, like every P&G plant, bids via software agents for its next production run based on its capability to deliver its current job, its queued work orders and its just-in-time materials supply capability. Its low-cost bid to produce Tide wins.



4 When pallets of Tide reach P&G's distribution centers, they're dynamically dispatched, with priority given to retailers whose inventories are very low.



5 When a tire blowout threatens to delay a shipment of Tide, P&G's agents detect it and prequalify an alternative trucker, who picks up the product and delivers it to Wal-Mart just in time.



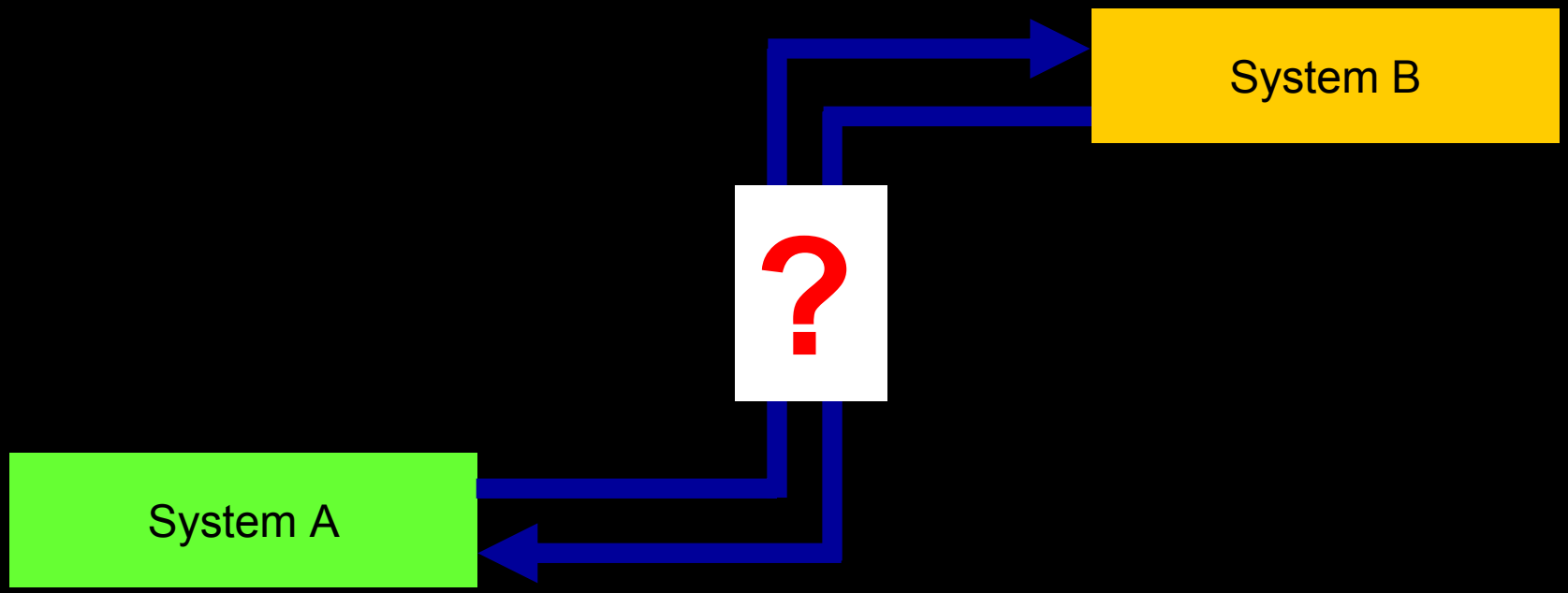
6 Wal-Mart has replaced all of its costly warehouses with docking facilities it shares with suppliers. These docking/distribution facilities ship products like Tide to stores within hours of receiving them.

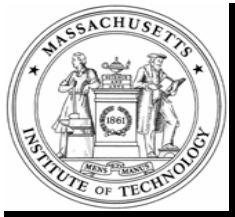
7 Software agents collect real-time sales data on each P&G product from multiple retail stores. They aggregate it and relay it to P&G's sales and marketing for trend analysis.

8 Wal-Mart's smart shelves alert a stocker to immediately retrieve Tide from the back room and place it on the shelf. Tide is restocked just seconds before the last box would have been taken off the shelf.

SOURCE: FORRESTER RESEARCH INC. AND

Global Data Synchronization





Electronic Product Code (64-bit)

01.0203D2A.916E8B.0719BAE03C

EPC

2^4

Header: 4 bits = 16

2^{16}

ePC Mgr: 16 bits = 65,536

2^{16}

Object Class: 16 bits = 65,536

2^{28}

Serial Number: 28 bits = 268, 435,456

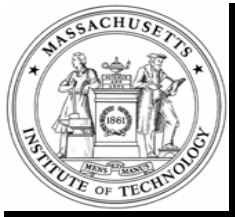
$2^{64} = 1.8 \times 10^{19}$

Designed for object identification as data from radio frequency tags, such as, RFID.

Not designed for syntax and information processes of the type who, where, when.

SOLUTION ??

Information Identification



Electronic Product Code (64-bit)

01.0203D2A.916E8B.0719BAE03C

EPC

$2^{64} = 1.8 \times 10^{19}$

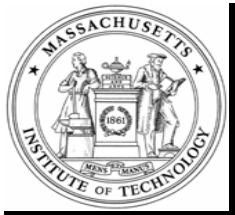
- Header: 4 bits = 16 — 2^4
- ePC Mgr: 16 bits = 65,536 — 2^{16}
- Object Class: 16 bits = 65,536 — 2^{16}
- Serial Number: 28 bits = 268, 435,456 — 2^{28}

21DA : 00D3 : 0000 : 2F3B : 02AA : 00FF : FE28 : 9C5A

IPv6

$2^{128} = 3.4 \times 10^{38}$

128-bit EPC form proposed in 1998 by Sanjay Sarma & Dan Engels of MIT is not used by EPC Global



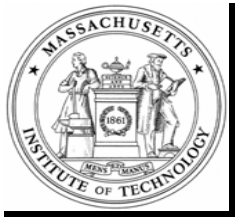
Why ? How ??

IPv6

Global Agreement

Internet Protocol version 6

But not necessarily a panacea!



Identification: Think Identity !

Relativistic Identification

Sir Clive Granger

Identical Results

Identical Numbers 120

Different Identities

120CG

120GS

Prof Gunnar Stefansson

Blood Glucose 120 mg/dl

Blood Glucose 120 mg/dl

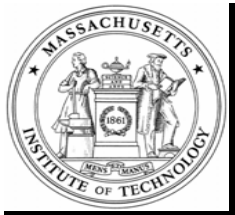
Executive Summary

- Concept — Relative Identification
- Application — Logistics, SCM, Healthcare, Security, eGov
- Tools — IPv6 Format and Semantics
- Benefits — Global Standard, Systems Interoperability

Problem Space

Object-centric Identification
Isolated, Inadequate, Heterogeneous

- Variable formats
- Systems incompatibility
- Master Data mis-Management
- Object data not linked to process
- Data, analytics, information - disconnected



- Variable formats
- Systems incompatibility

- **GIAI – Global Individual Asset Identifier**
- **GLN – Global Location Number**
- **SSCC – Serialized Shipping Container Code**
- **GTIN – Global Trade Item Number**
- **GUID – Globally Unique Identification**
- **UCR – Universal Consignment Reference**
- **EPC – Electronic Product Code**

Master (?) Data mis-Management

Manual Identification

Here

METRO AG
Heinz Ketchup
Store Id 6174523211

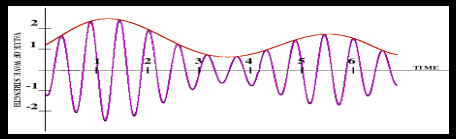
Store Database

Regional DC Database

3PL Database

Warehouse Database

RFID: Automatic Identification



01.0203D2A.916E8B.0719BAE03C

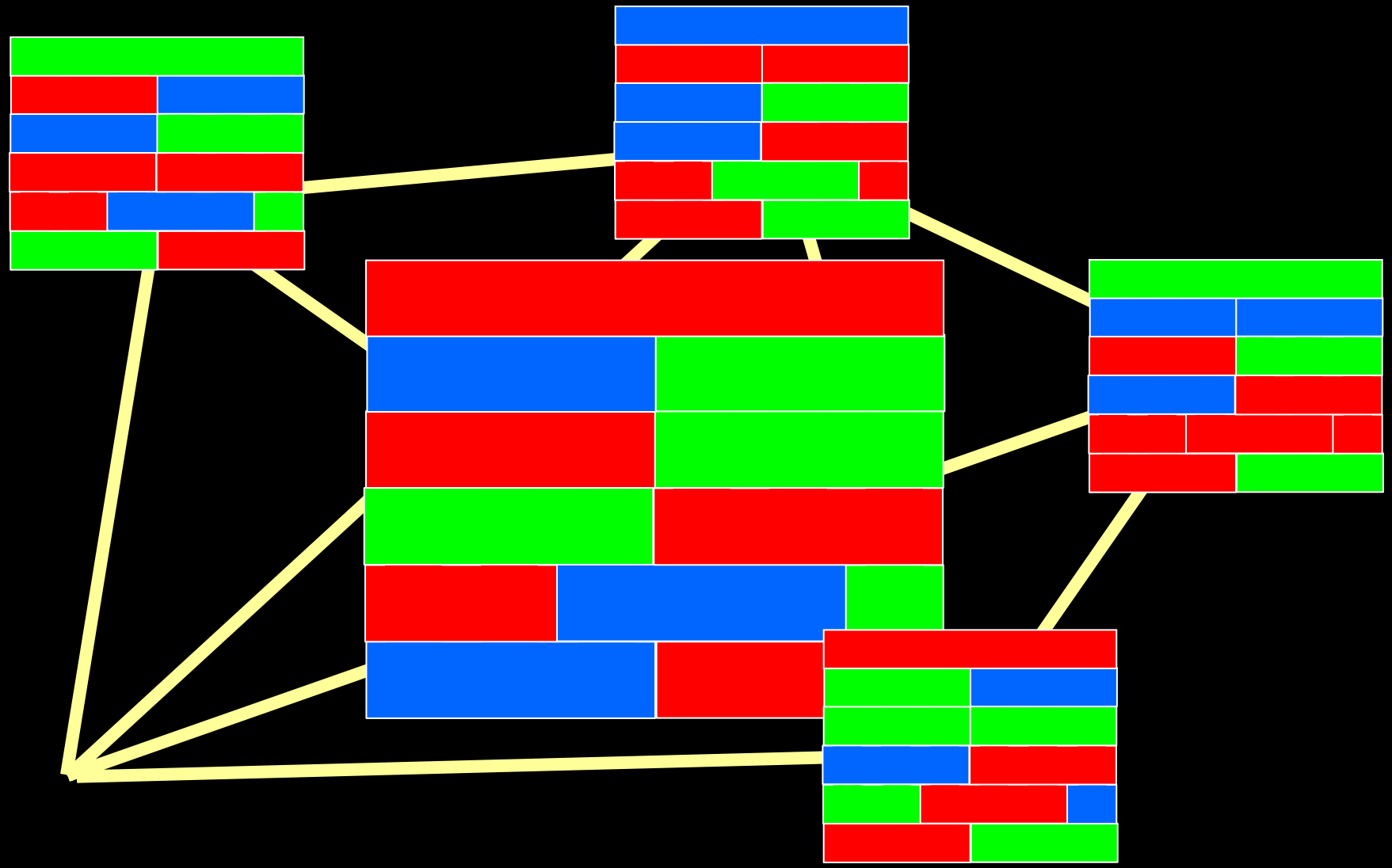
There

Heinz Ketchup
Manufacturer's EPC
010203D2A916E8B

Manufacturer's Database

Systems Incompatibility, Master Data mis-Management

Networks Lack Functional Integration, Interoperability



Systems Solution Requires

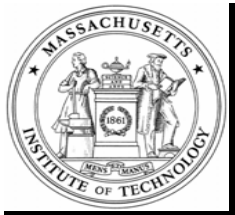
Unique Identification Objects, Process, Information, Decisions

- Not a new standard format
- Heterogeneous systems compatibility
- Syntax and semantic relationships - defined
- Data, analytics, process, information - linked

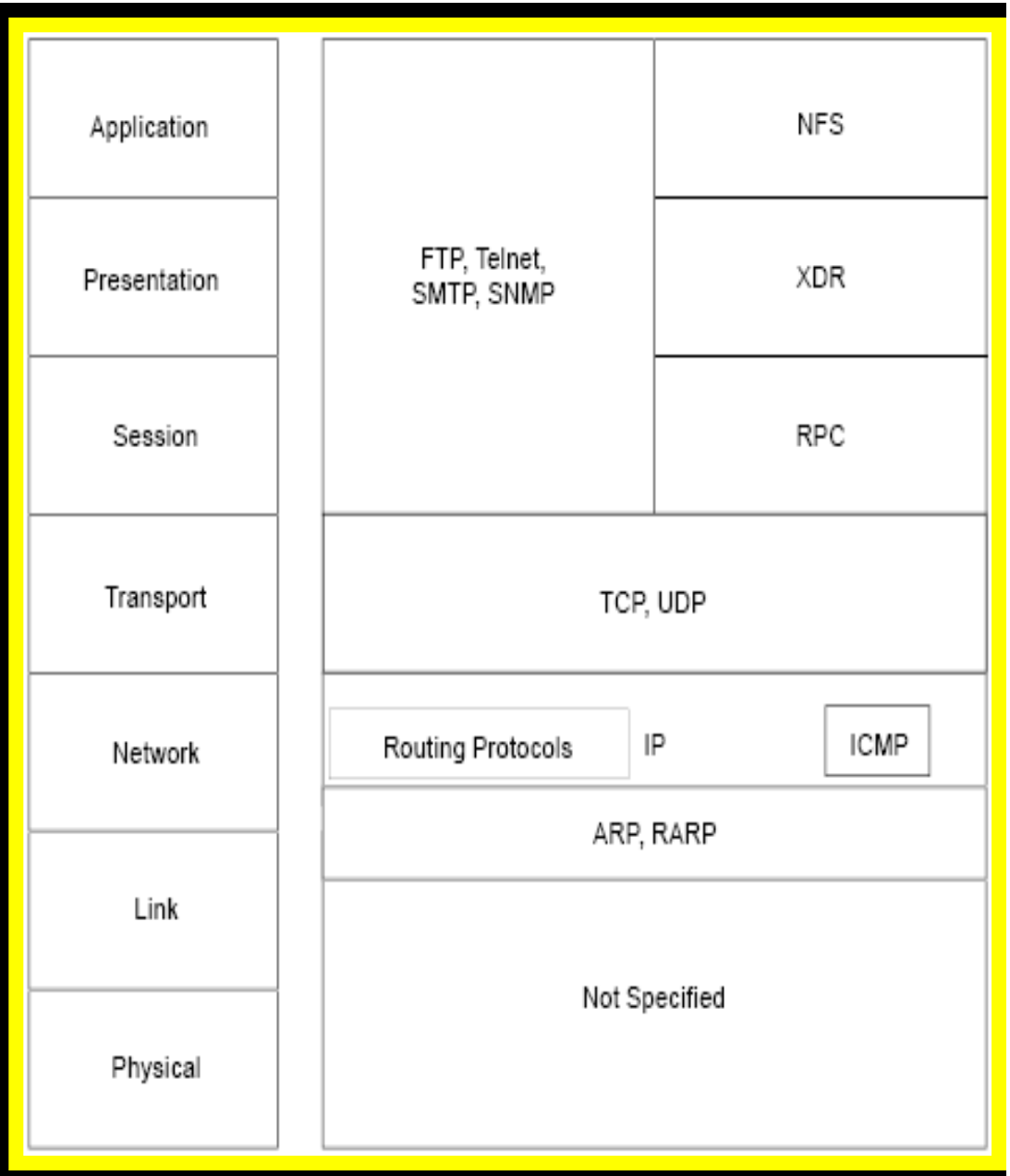
Proposed Solution

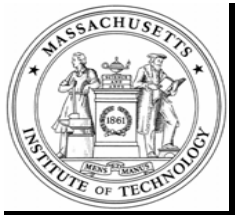
IPv6
Use Internet Protocol version 6 Format

- Not a new standard – agreed for adoption
- Heterogeneous systems compatibility - proven
- Syntax & semantics – unique id possible using URI
- Data, analytics, process, information – can be linked



IPv6


Application
Presentation
Session
Transport
Network
Link
Physical
FTP, Telnet, SMTP, SNMP
NFS
XDR
RPC
TCP, UDP
Routing Protocols
IP
ICMP
ARP, RARP
Not Specified
OSI Reference Model
Internet Protocol Suite



IPv6 Format

128-bit IPv6 address in binary form is divided along 16-bit boundaries:

0010000111011010 0000000011010011 0000000000000000 0010111100111011

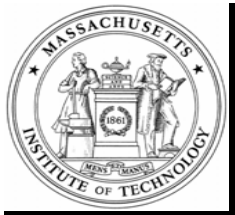
0000001010101010 0000000011111111 1111111000101000 1001110001011010

Each 16-bit block converted to colon hexadecimal form

21DA : 00D3 : 0000 : 2F3B : 02AA : 00FF : FE28 : 9C5A

With leading zero suppression

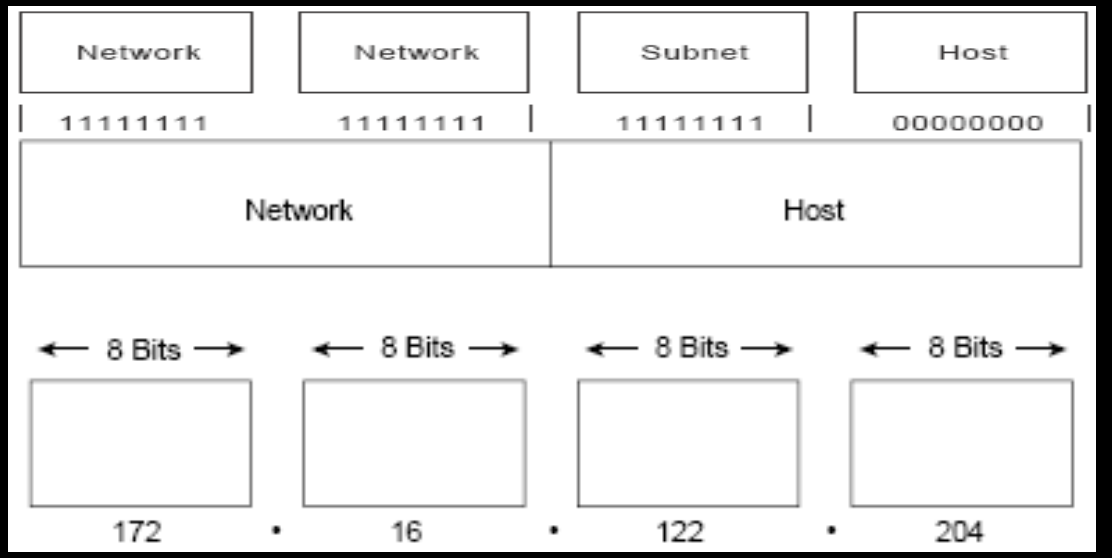
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A



2^{32}

IPv4

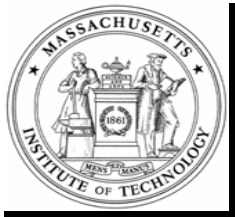
151•193•204•72



21DA : 00D3 : 0000 : 2F3B : 02AA : 00FF : FE28 : 9C5A

2^{128}

IPv6



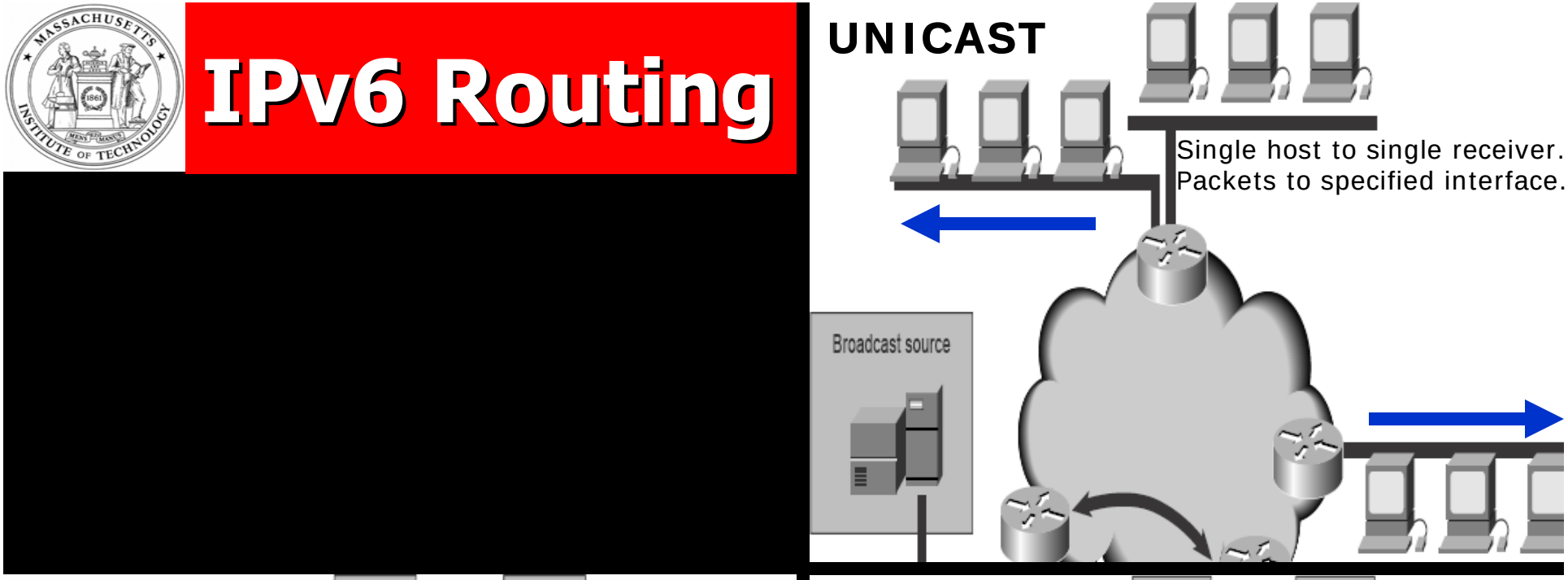
Routing

IPv6

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A

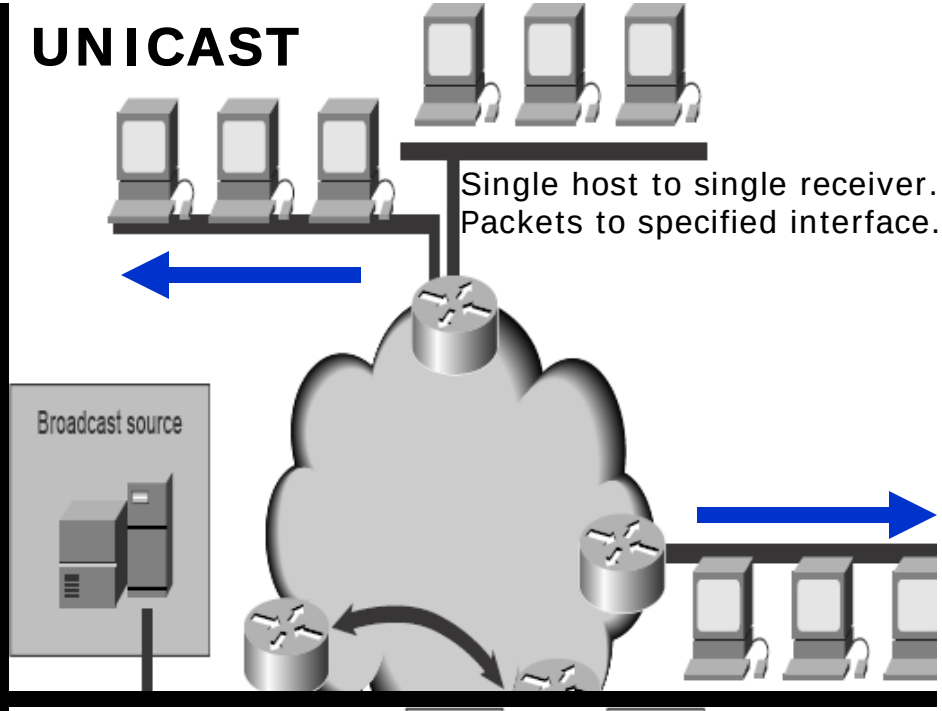
-
-
-
- Data, analytics, process, information – transmission
- New revenue potential for telecommunications including P2P
- Not everything needs routing but **FORMAT** is globally adopted

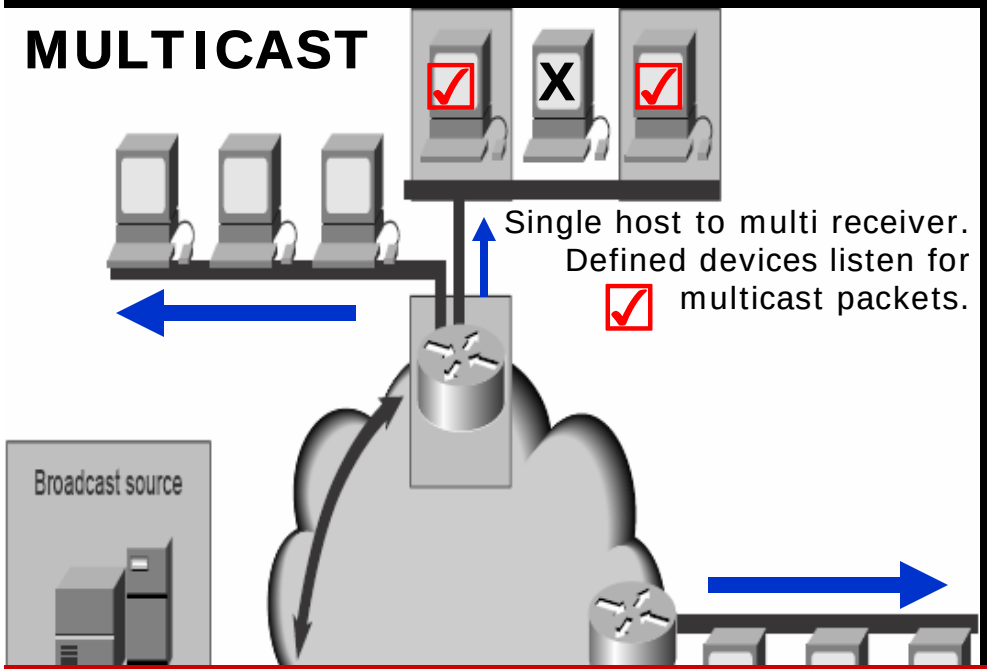
IPv6 Routing

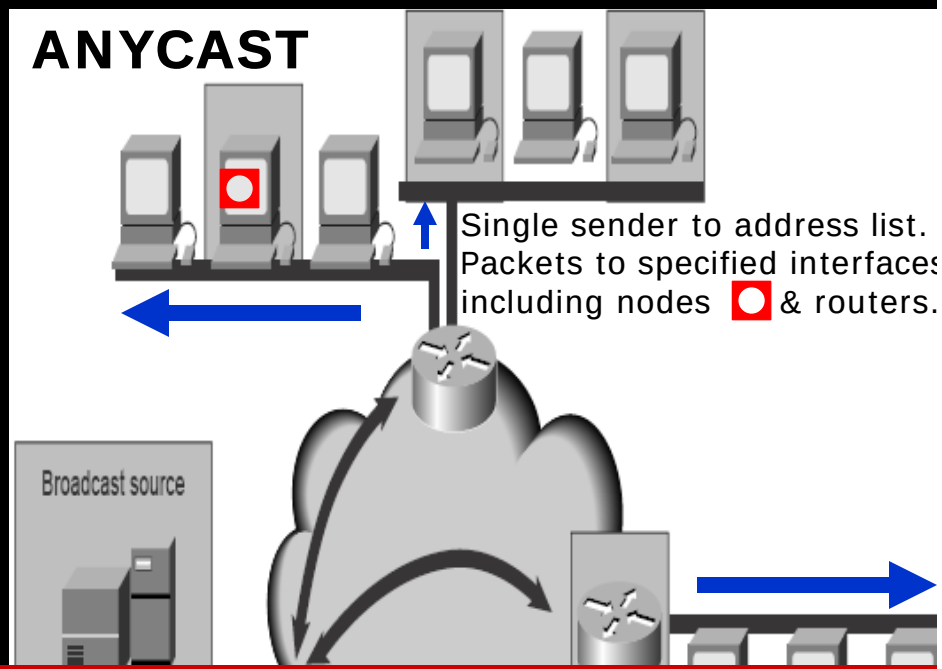


IPv6 Routing

How is this helpful in operations?





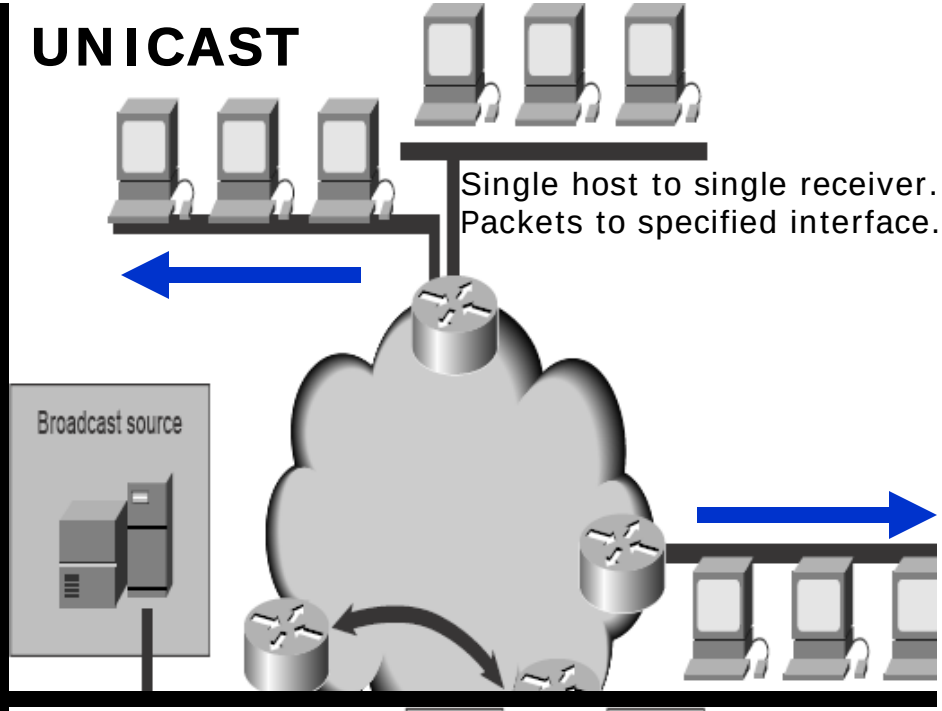


IPv6 Routing

Data Routing

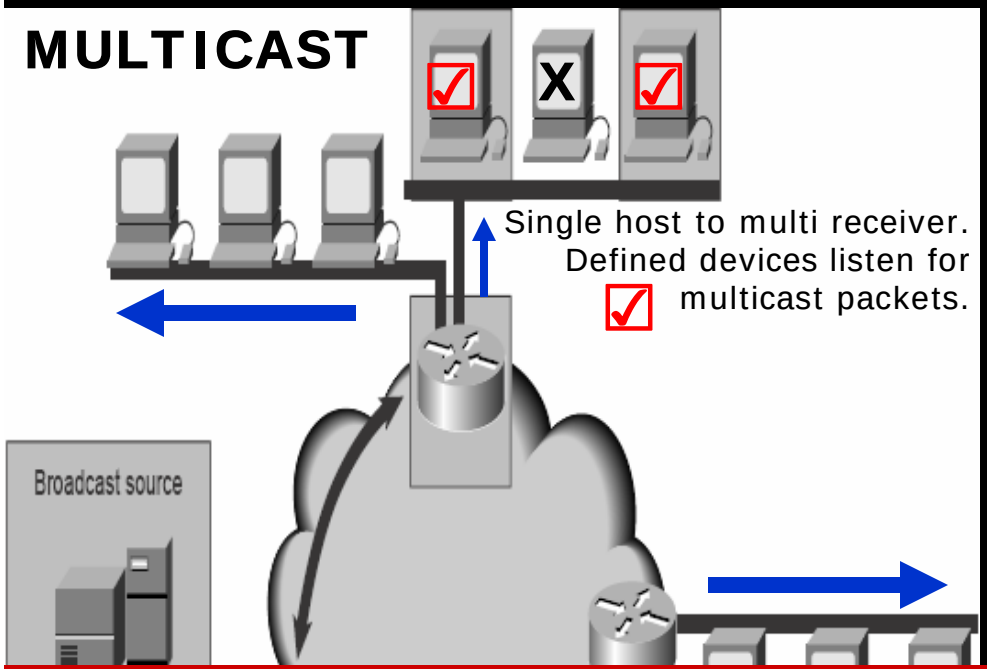
- *Where ?*
- *What ?*

UNICAST



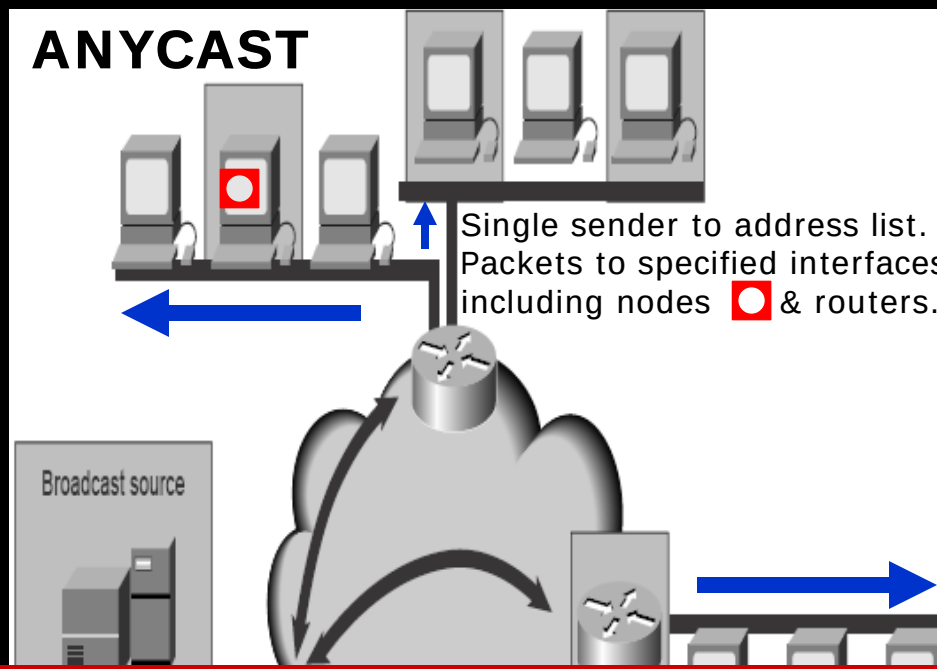
Single host to single receiver.
Packets to specified interface.

MULTICAST



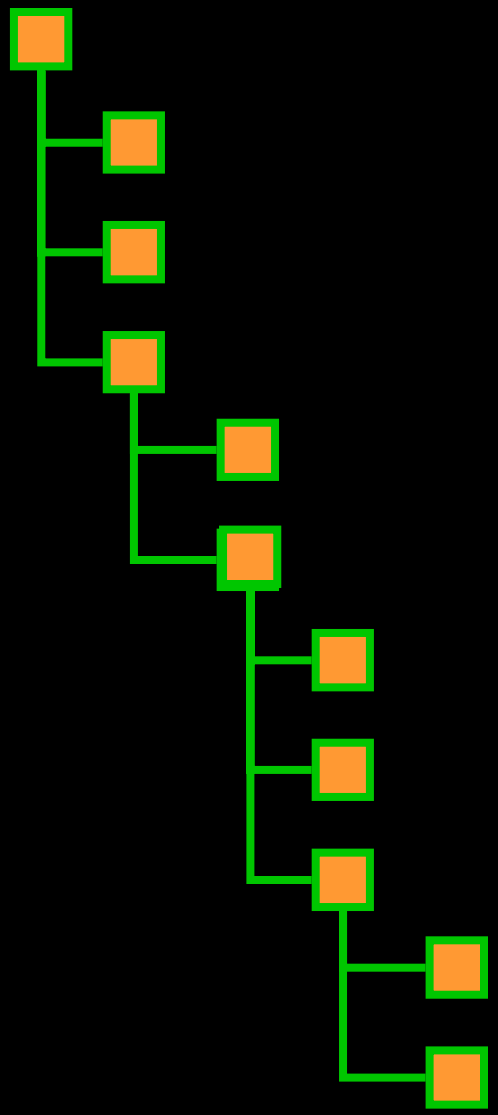
Single host to multi receiver.
Defined devices listen for
☑ multicast packets.

ANYCAST

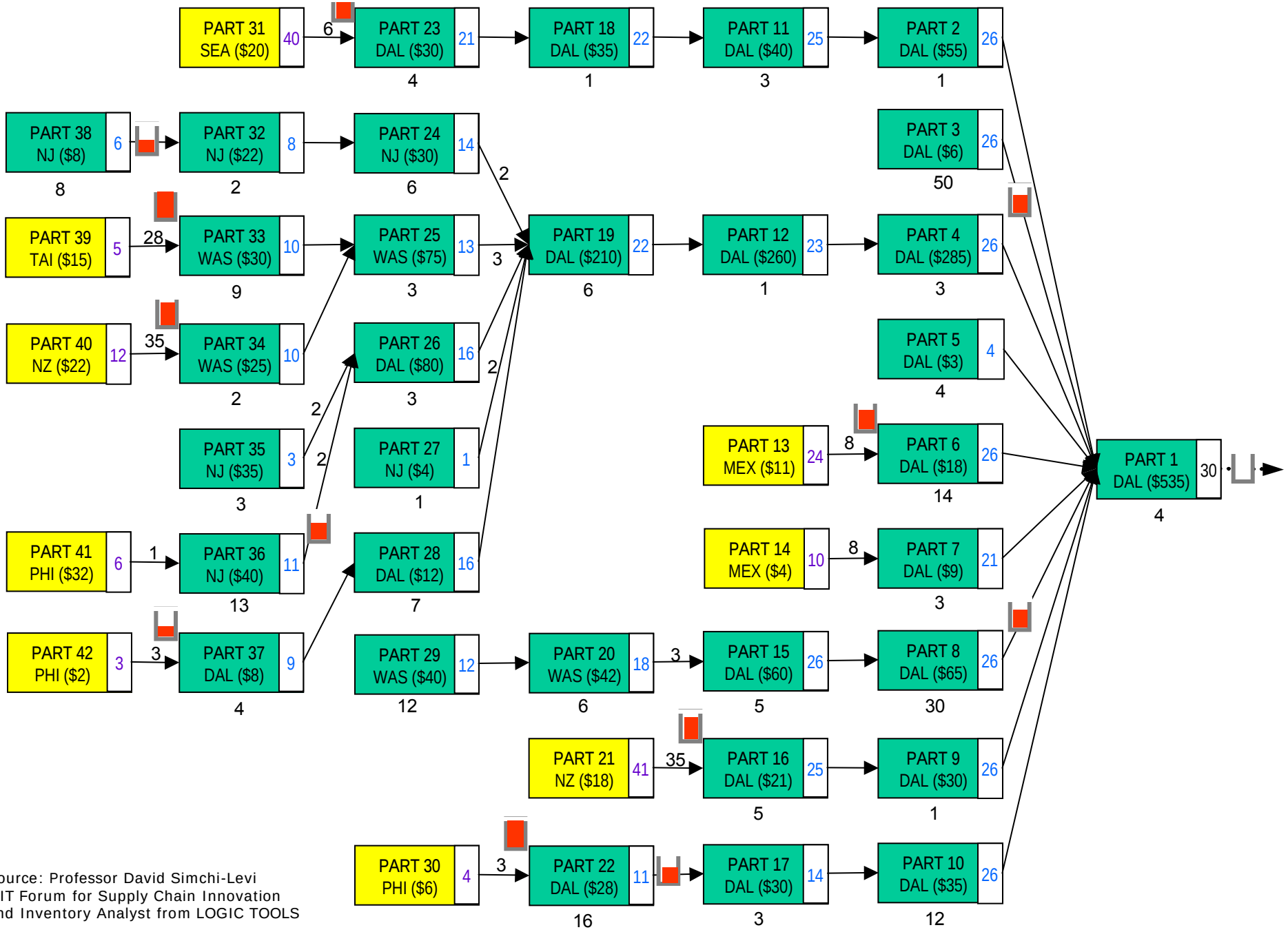


Single sender to address list.
Packets to specified interfaces
including nodes ◯ & routers.

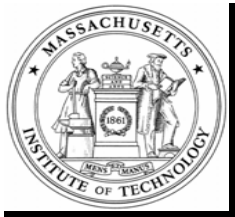
Sets, Subsets, Identification, Relation, Data



Components: Inventory Optimization in Supply Chain



Source: Professor David Simchi-Levi
MIT Forum for Supply Chain Innovation
and Inventory Analyst from LOGIC TOOLS



Billions of Objects

3.0	J & J
10.0	Kimberly Clark
15.0	Tesco
20.0	Unilever
25.0	Philip Morris
30.0	Wal-Mart
31.0	P&G
53.0	International Paper
200.0	Coca-Cola
205.0	US Post

Trillions of Processes

Octillions of Identities

32-bit address space (IPv4) allows 2^{32} or 4,294,967,296 possible unique addresses (id). A 128-bit address space used for the design of the IP version 6 allows for 2^{128} or 340,282,366,920,938,463,463,374,607,431,768,211,456 (3.4×10^{38}) possible unique addresses. EPC is a 64-bit format for 18,446,744,073,709,551,616 or 1.8×10^{19} unique object id. 96-bit identifies 79,228,162,514,264,337,593,543,950,336 (7.9×10^{28}) objects with RFID tags but excludes “process” id.

Mobile Dynamic Network

Billions of Objects

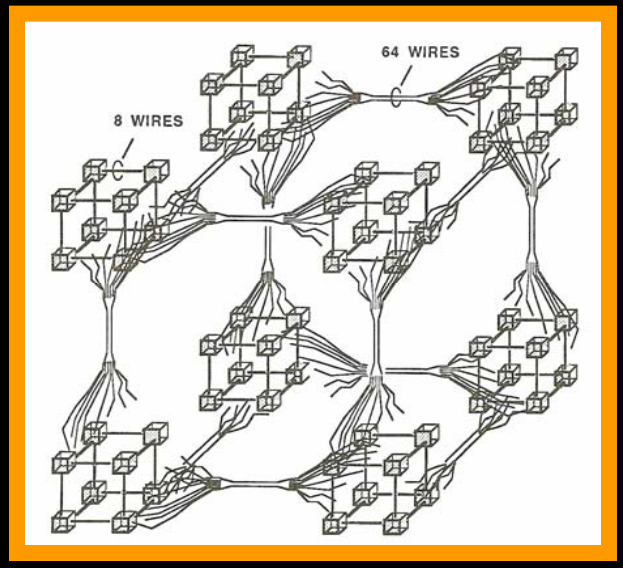
Trillions of Processes

Octillions of Identities

Exabytes of Data

SCM Logistics Transportation

- Manufacturer
  - 3PL
  - Goods Receipt
  - Distribution Planning
    - Transportation Zone
    - Distribution Center
      - Store Identifier
      - Receiving Personnel
      - Plan-o-gram Compliance
        - Shelf
        - B/A Value-Pack Present
          - GIFT BOX RFID Tag
          - GIFT BOX Acrylic Casing
          - GIFT BOX
            - WiMax-WiFi Connect Card
            - GIFT SET
              - XBOX GAME
              - CD Book+Soundtrack
              - DVD Item
                - DVD Disc
                - DVD Case



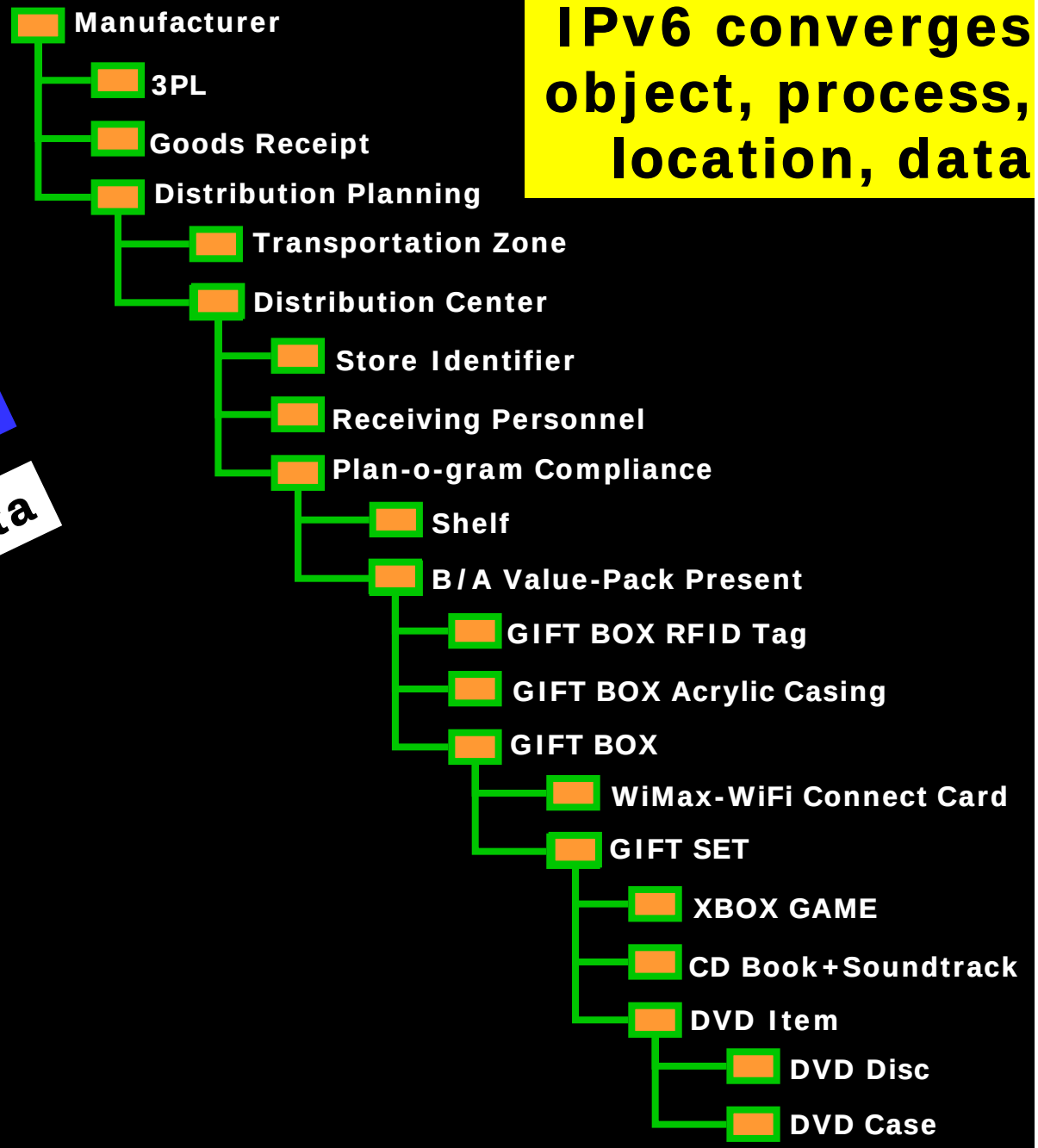
Why IPv6

Billions of Objects

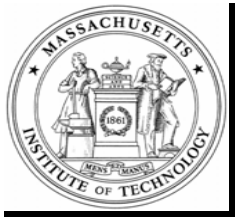
Trillions of Processes

Octillions of Identities

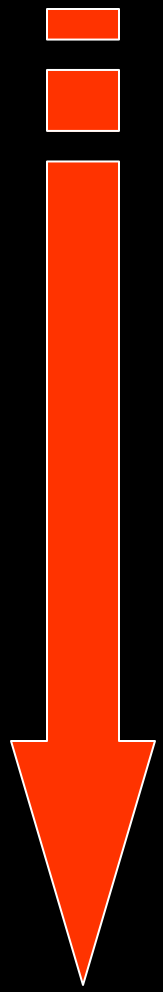
Exabytes of Data



IPv6 converges object, process, location, data

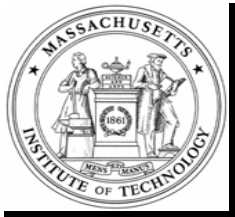


IPv6 converges object, process location, data

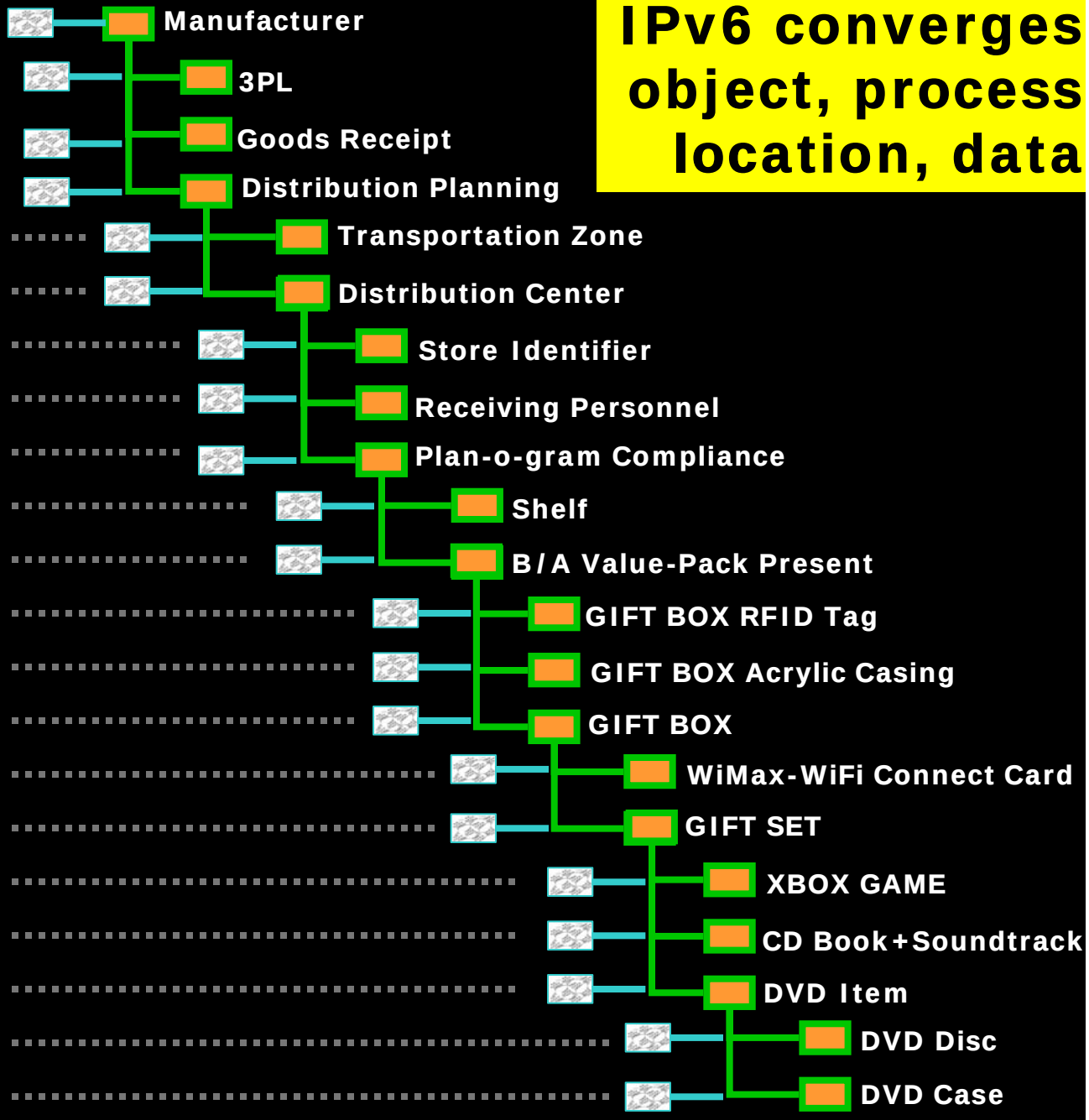


- Manufacturer
  - 3PL
  - Goods Receipt
  - Distribution Planning
    - Transportation Zone
    - Distribution Center
      - Store Identifier
      - Receiving Personnel
      - Plan-o-gram Compliance
        - Shelf
        - B/A Value-Pack Present
          - GIFT BOX RFID Tag
          - GIFT BOX Acrylic Casing
          - GIFT BOX
            - WiMax-WiFi Connect Card
            - GIFT SET
              - XBOX GAME
              - CD Book+Soundtrack
              - DVD Item
                - DVD Disc
                - DVD Case

21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D

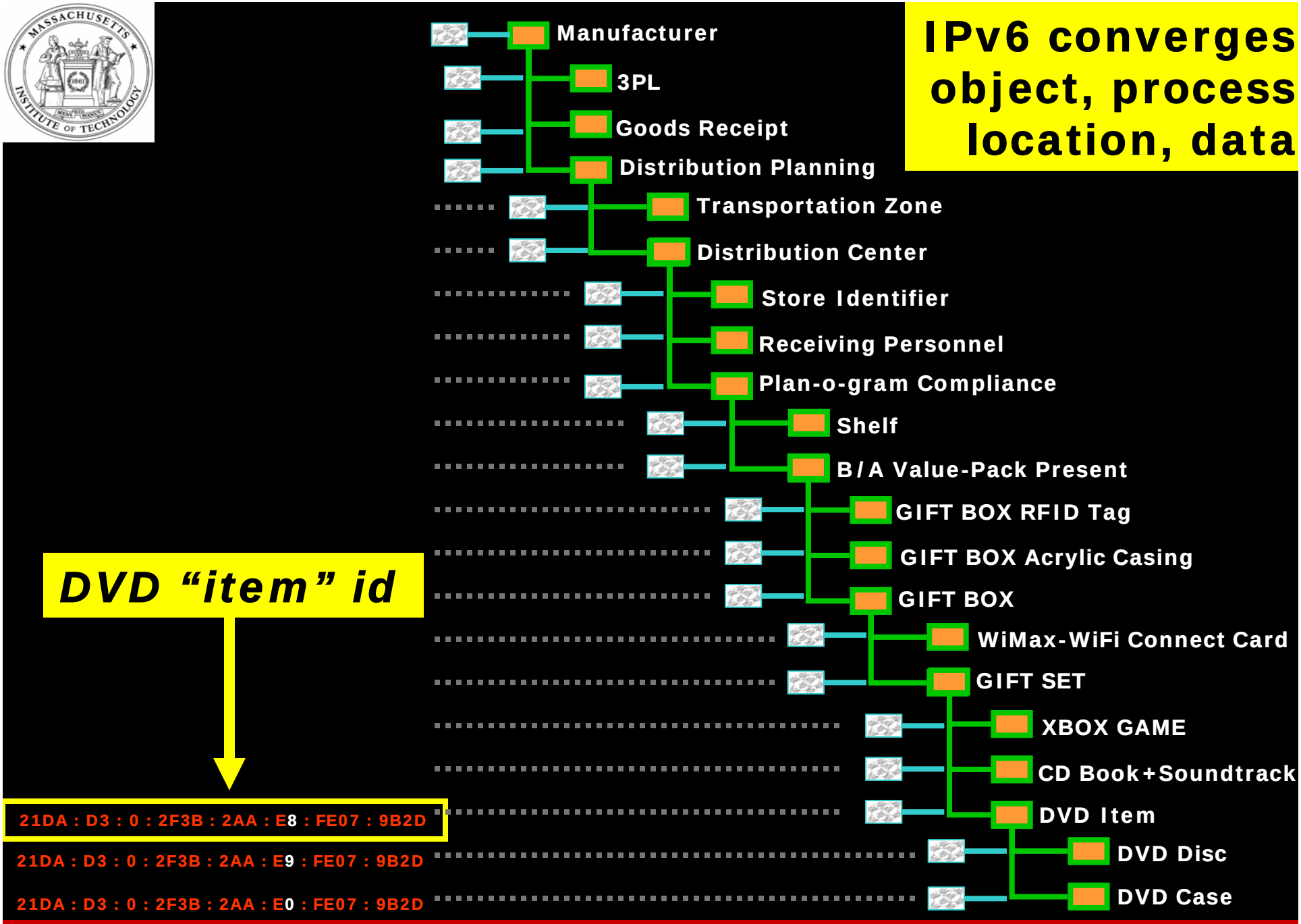


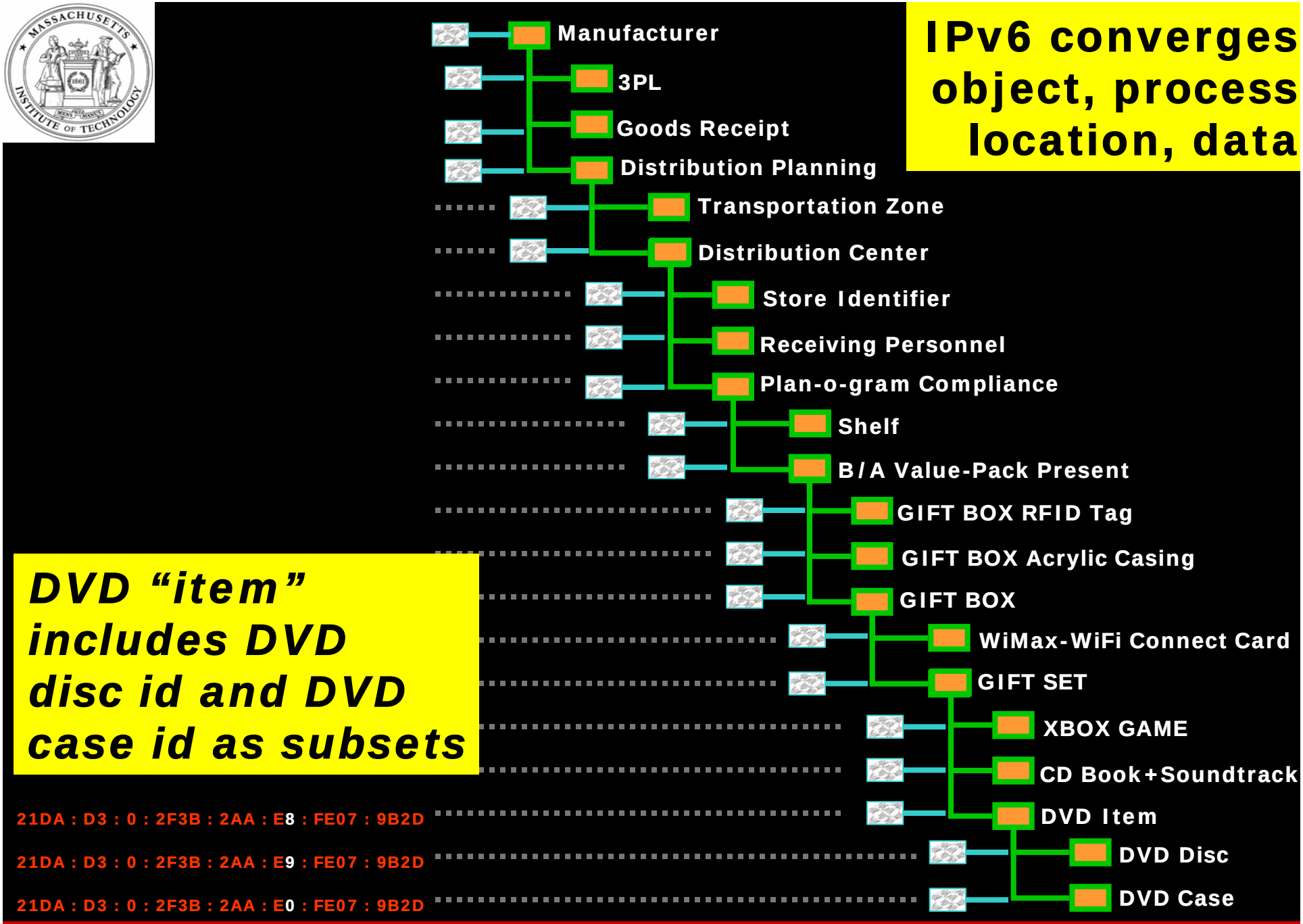
IPv6 converges object, process location, data



21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D

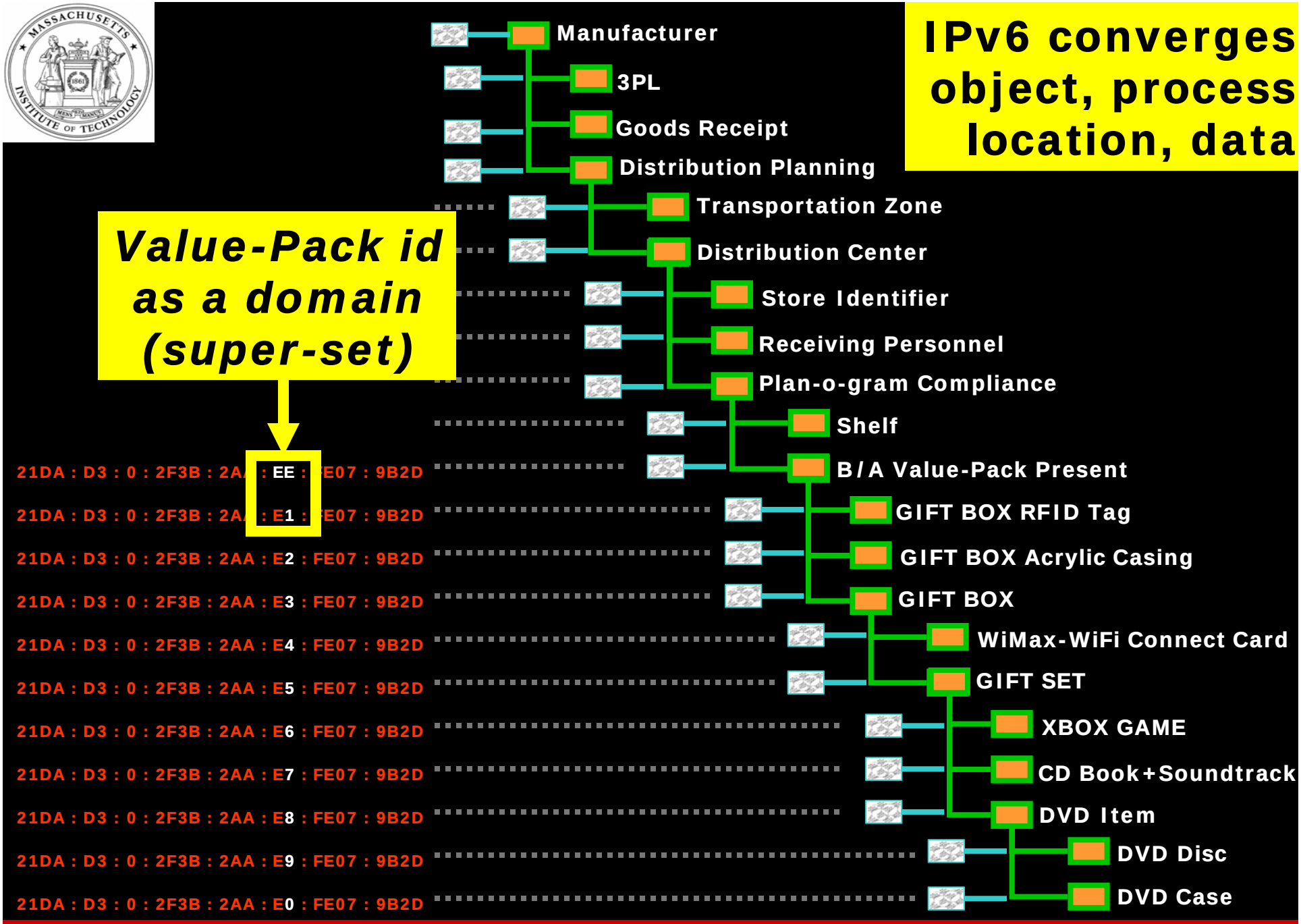
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D


IPv6 converges object, process location, data
Manufacturer
3PL
Goods Receipt
Distribution Planning
Transportation Zone
Distribution Center
Store Identifier
Receiving Personnel
Plan-o-gram Compliance
Shelf
B/A Value-Pack Present
GIFT BOX RFID Tag
GIFT BOX Acrylic Casing
GIFT BOX
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case
DVD "item" id
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D



IPv6 converges object, process location, data

DVD "item" includes DVD disc id and DVD case id as subsets


IPv6 converges object, process location, data
Value-Pack id as a domain (super-set)
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D
Manufacturer
3PL
Goods Receipt
Distribution Planning
Transportation Zone
Distribution Center
Store Identifier
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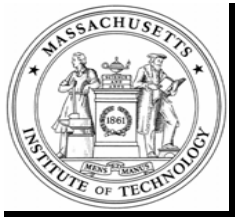
GIFT BOX Acrylic Casing
GIFT BOX
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case



IPv6 converges object, process location, data

Value-Pack id as a domain (super-set)

21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D

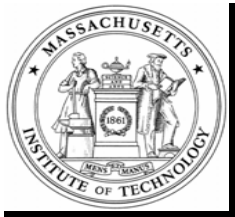
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D

Re-inventing

EPC ?



Electronic Product Code (64-bit)

01.0203D2A.916E8B.0719BAE03C

EPC

2^4

Header: 4 bits = 16

2^{16}

ePC Mgr: 16 bits = 65,536

2^{16}

Object Class: 16 bits = 65,536

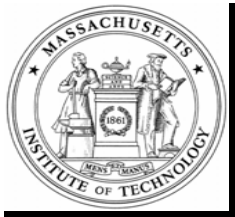
2^{28}

Serial Number: 28 bits = 268, 435,456

$2^{64} = 1.8 \times 10^{19}$

Designed for object identification as data from radio frequency tags, such as, RFID.

Not designed for syntax and information processes of the type who, where, when.



IPv6 converges object, process location, data mapping EPC

Value-Pack id as a domain (super-set)

21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D

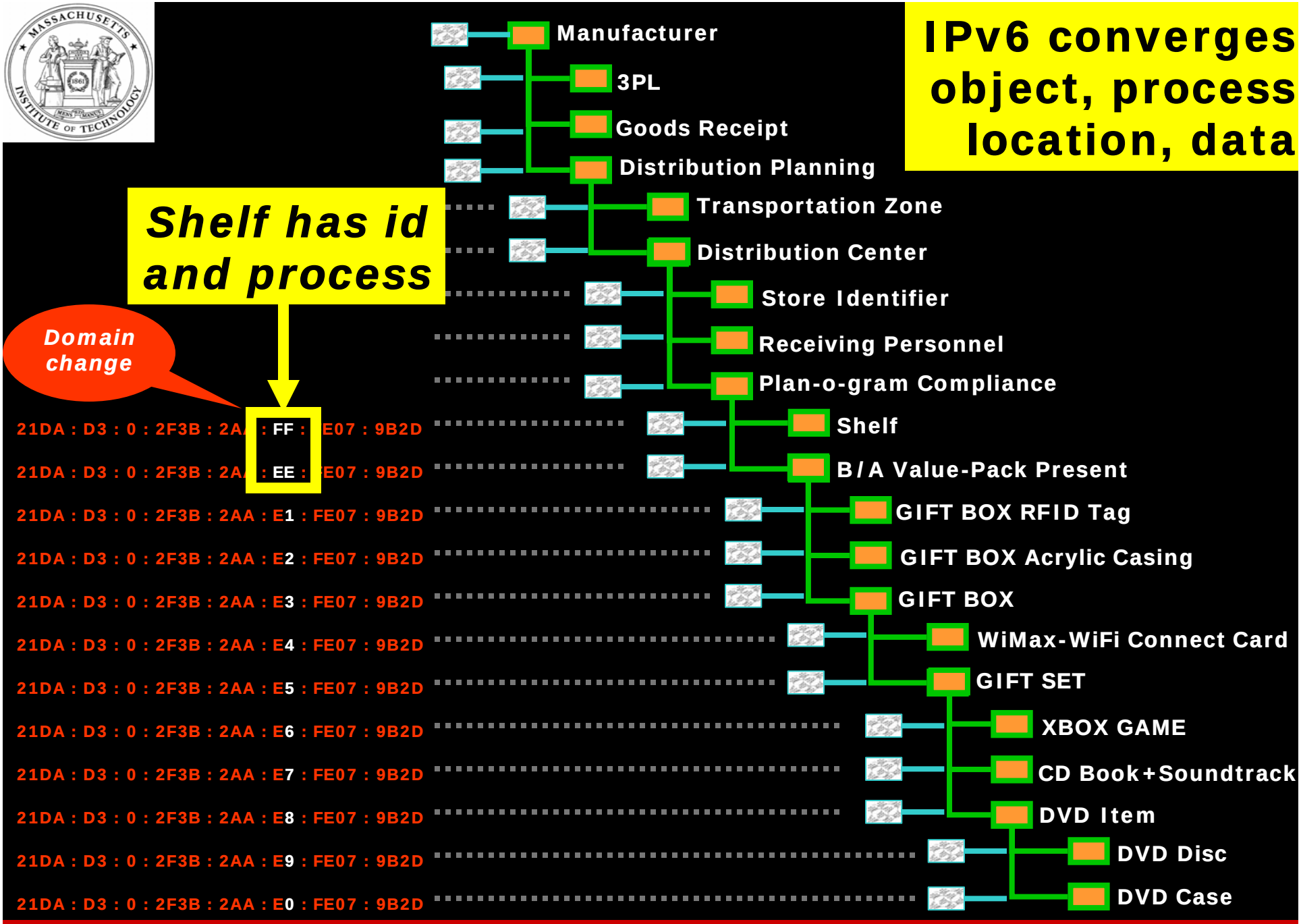
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D

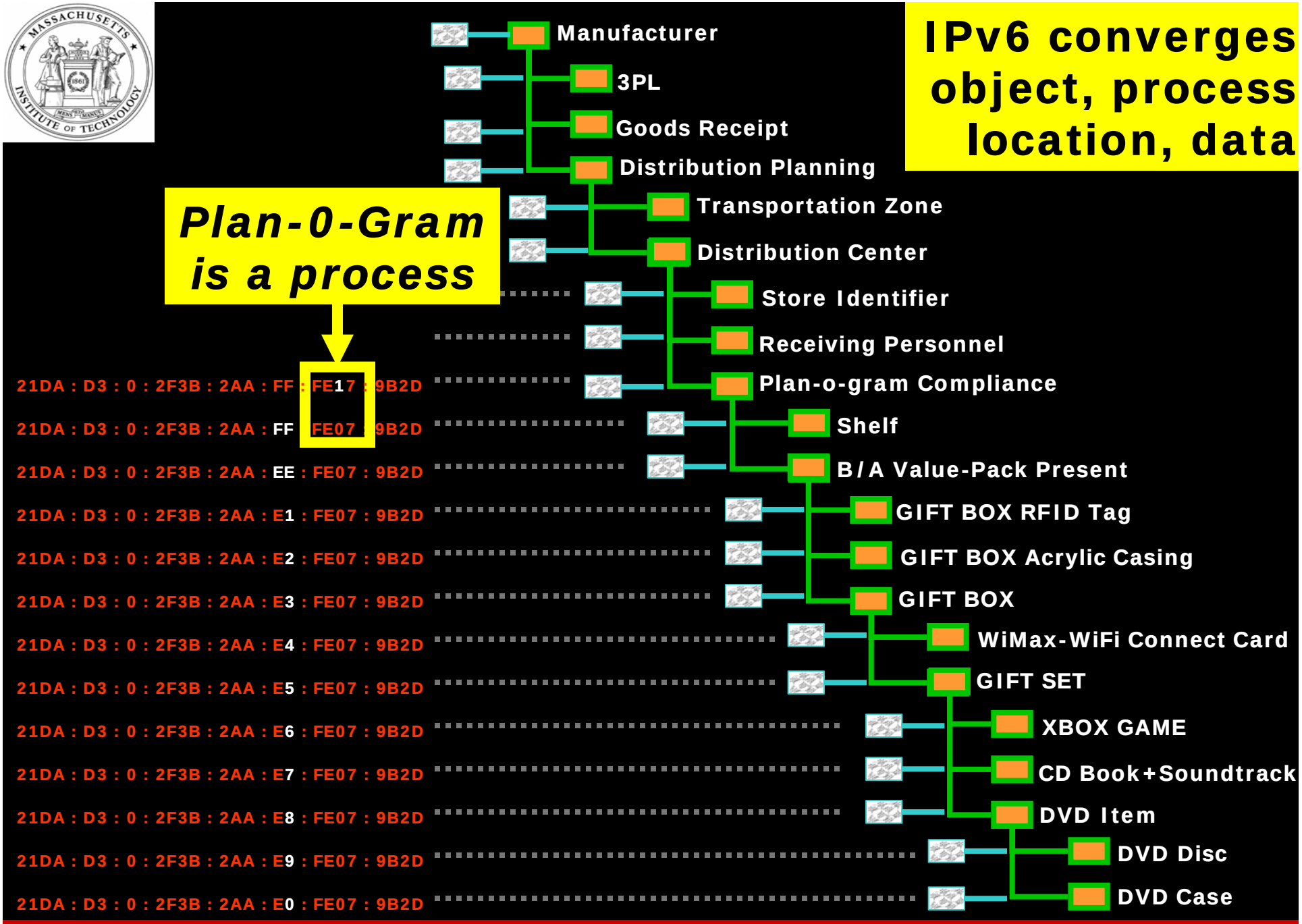
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D

Map EPC to IPv6

01.0203D2A.916E8B.0719BAE03C


IPv6 converges object, process location, data
Shelf has id and process
Domain change
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D
Manufacturer
3PL
Goods Receipt
Distribution Planning
Transportation Zone
Distribution Center
Store Identifier
Receiving Personnel
Plan-o-gram Compliance
Shelf
B/A Value-Pack Present
GIFT BOX RFID Tag
GIFT BOX Acrylic Casing
GIFT BOX
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case


IPv6 converges object, process location, data
Plan-0-Gram is a process
Manufacturer
3PL
Goods Receipt
Distribution Planning
Transportation Zone
Distribution Center
Store Identifier
Receiving Personnel
Plan-o-gram Compliance
Shelf
B/A Value-Pack Present
GIFT BOX RFID Tag
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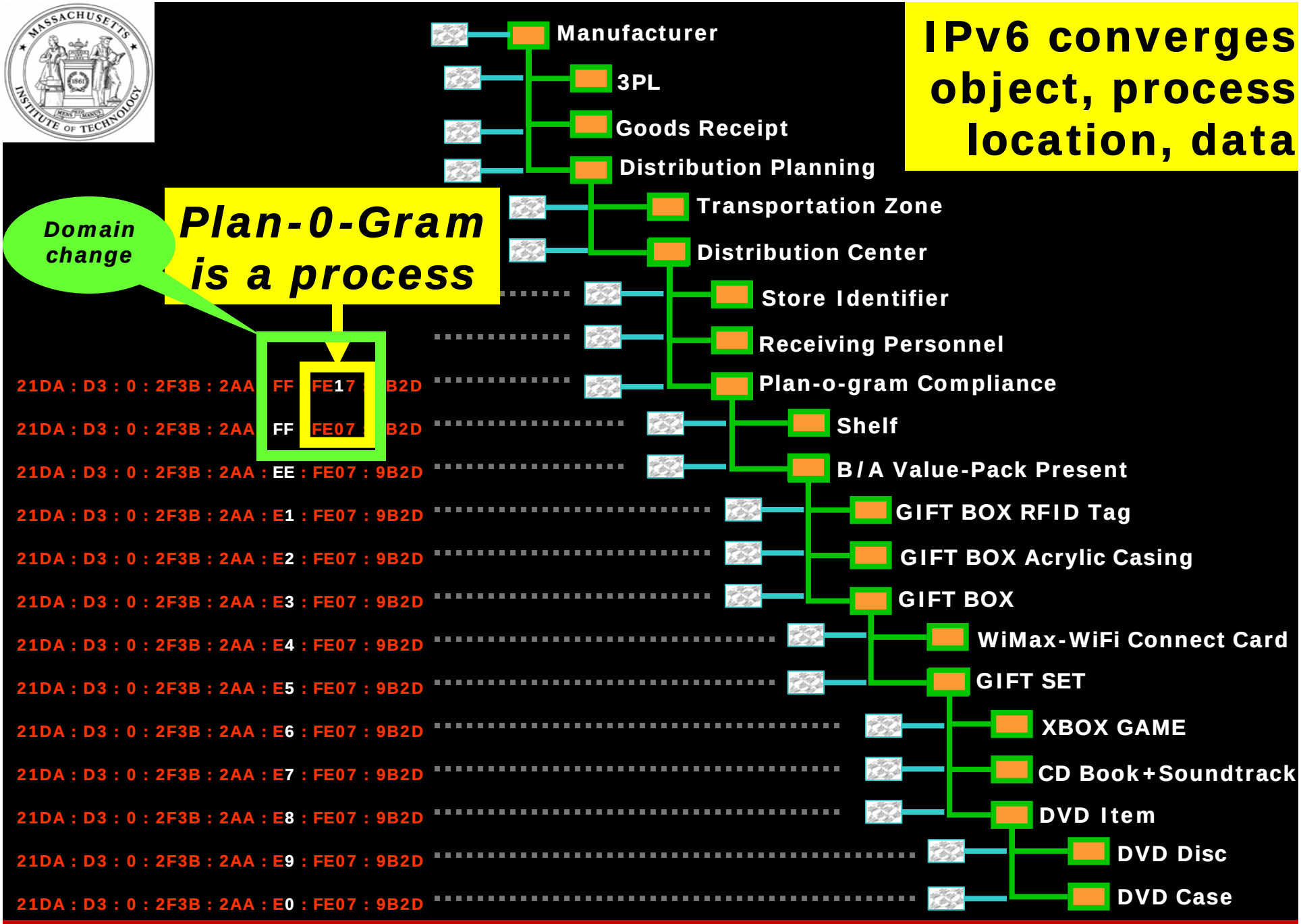
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D


IPv6 converges object, process location, data
Plan-0-Gram is a process
Domain change
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D
Manufacturer
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Goods Receipt
Distribution Planning
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Store Identifier
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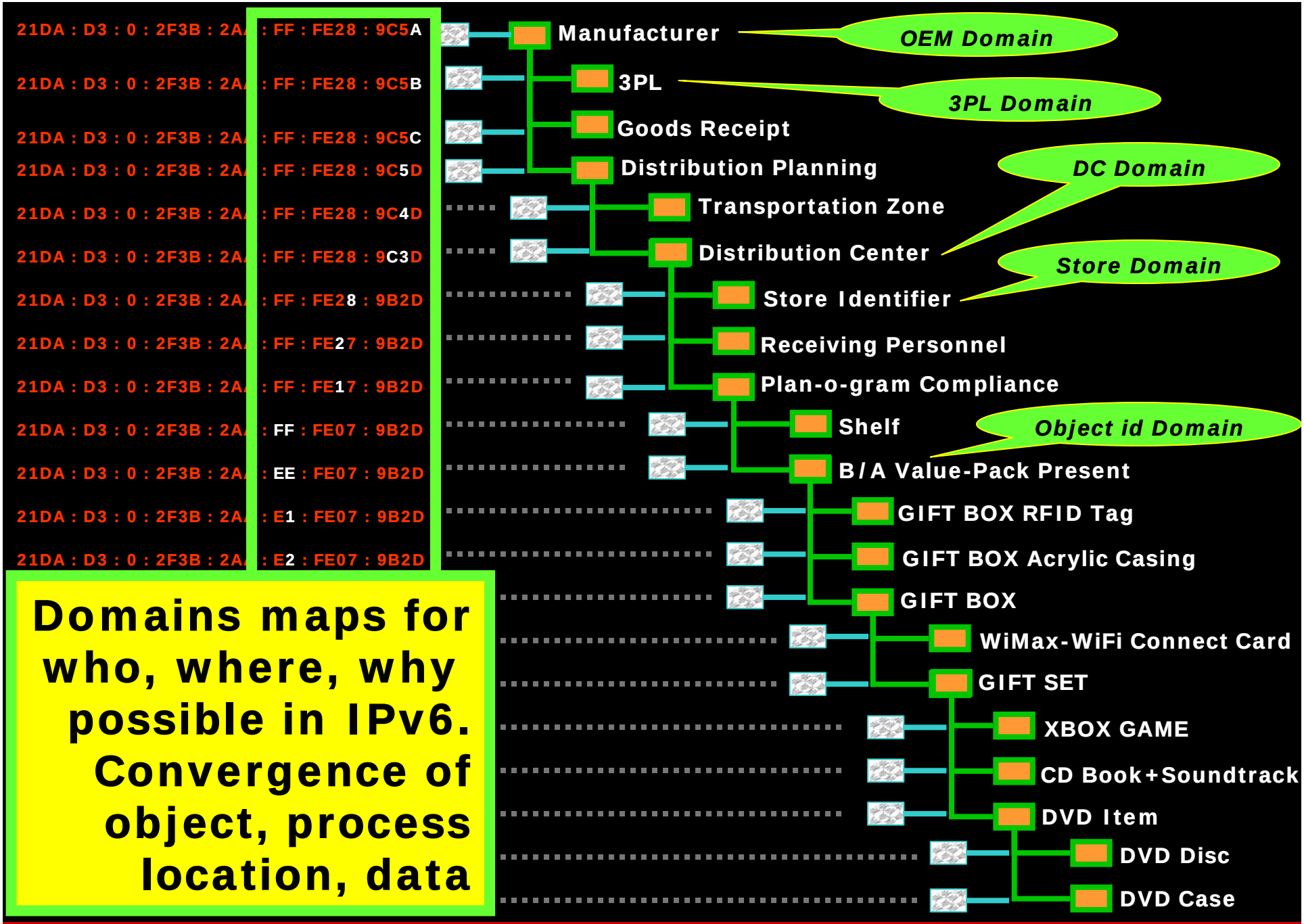
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C5A
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C5B
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C5C
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C5D
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C4D
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9C3D
21DA : D3 : 0 : 2F3B : 2A : FF : FE28 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : FF : FE27 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : FF : FE17 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : E1 : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2A : E2 : FE07 : 9B2D
Manufacturer
3PL
Goods Receipt
Distribution Planning
Transportation Zone
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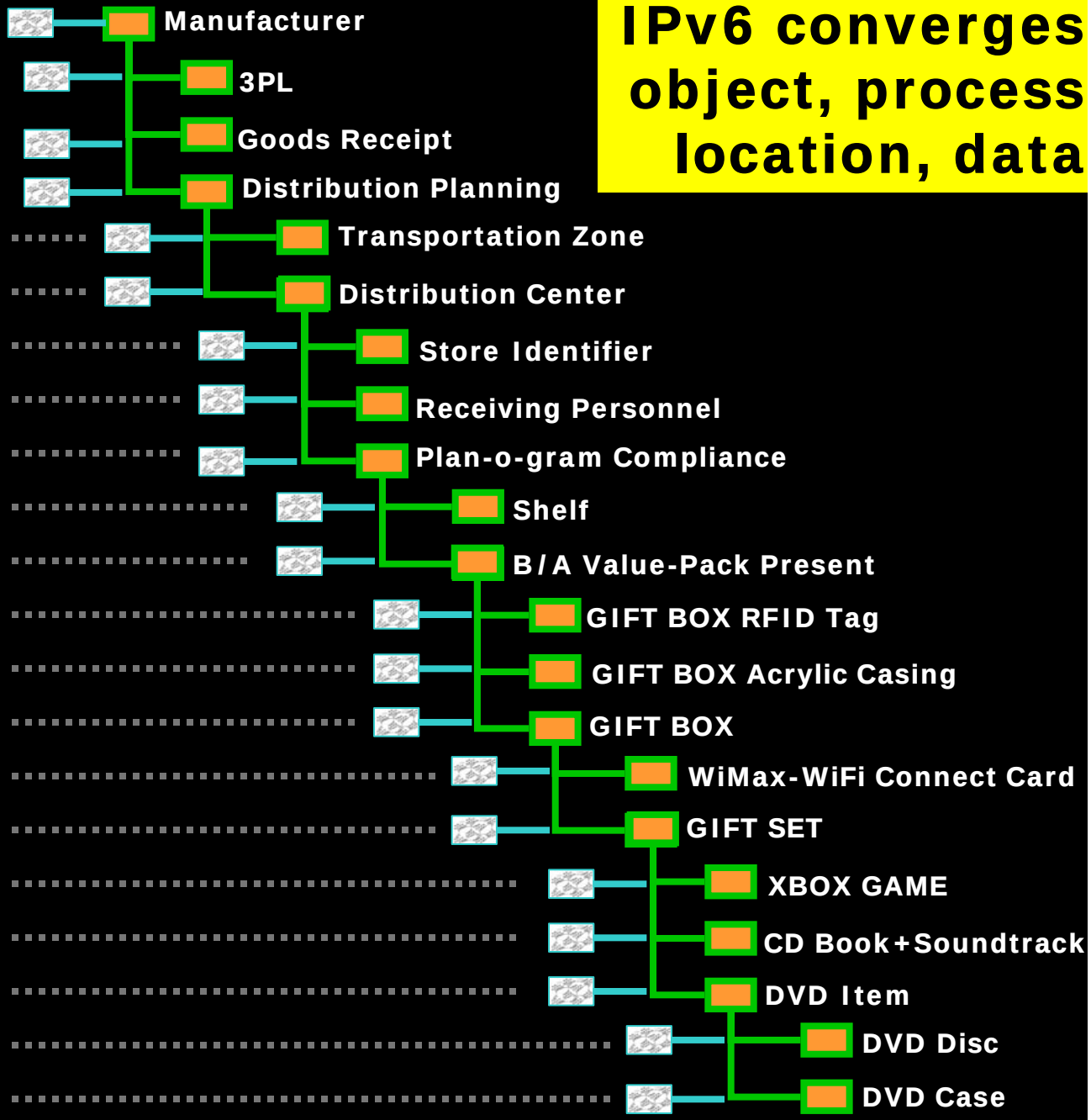
GIFT BOX
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case
OEM Domain
3PL Domain
DC Domain
Store Domain
Object id Domain
Domains maps for who, where, why possible in IPv6. Convergence of object, process location, data

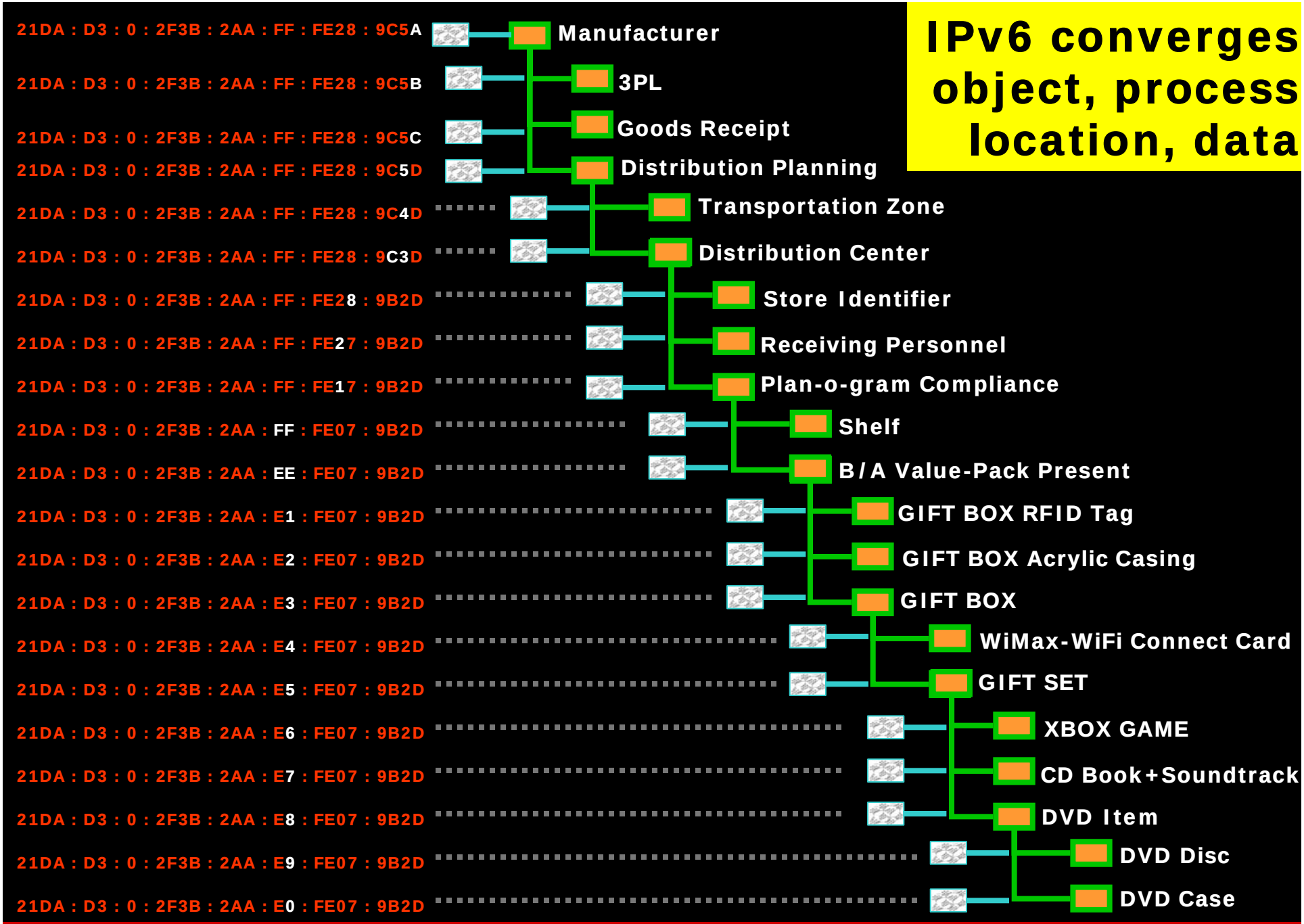
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A

Unique id relates to all information and data subsets.

IPv6 converges object, process location, data



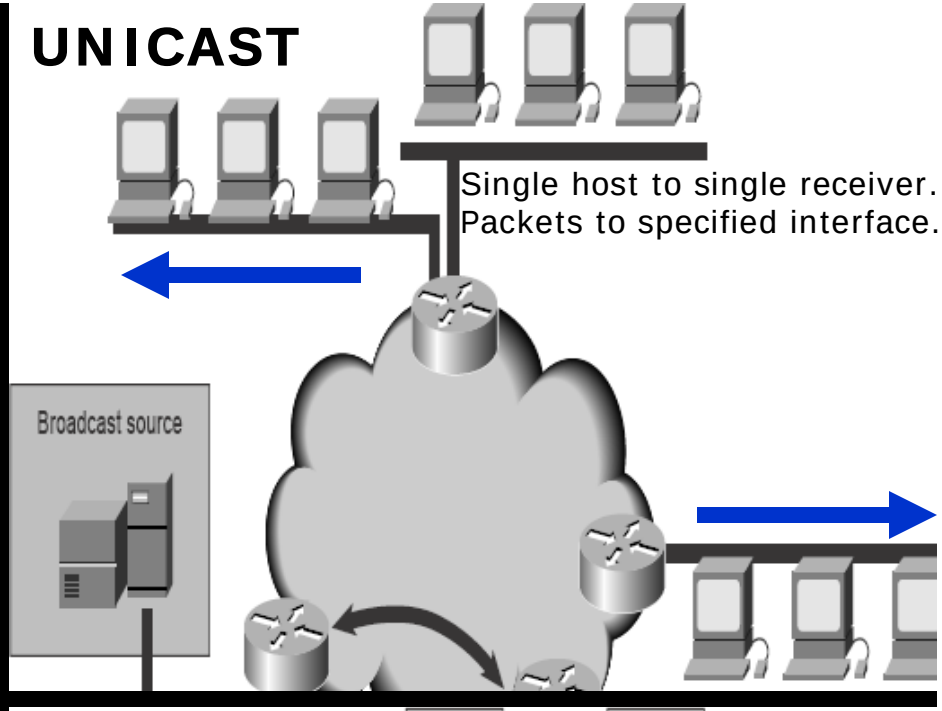
IPv6 converges object, process location, data



IPv6 Routing

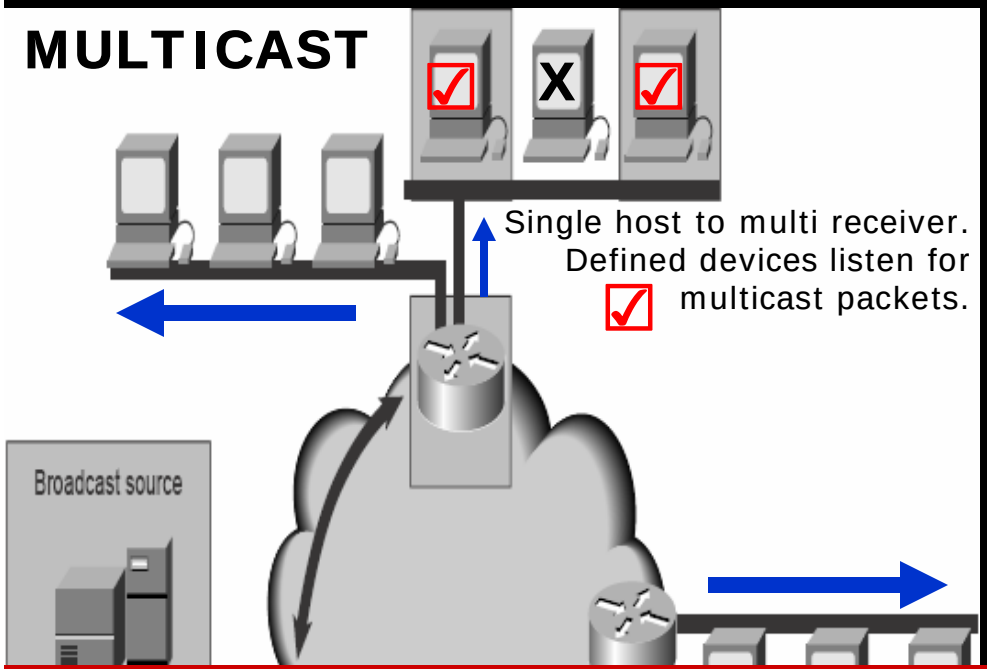
How is this helpful in operations?

UNICAST



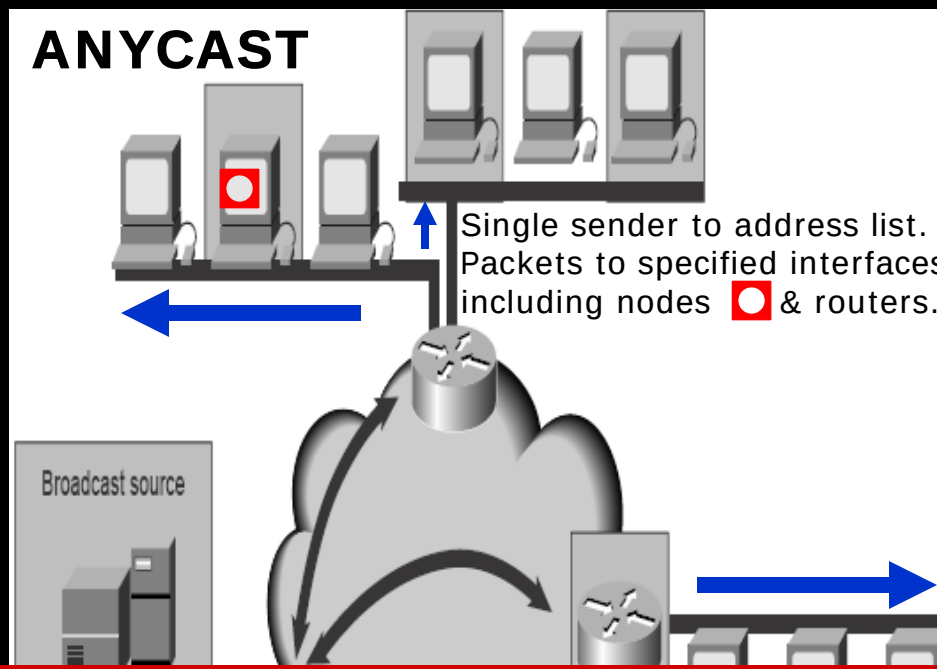
Single host to single receiver.
Packets to specified interface.

MULTICAST

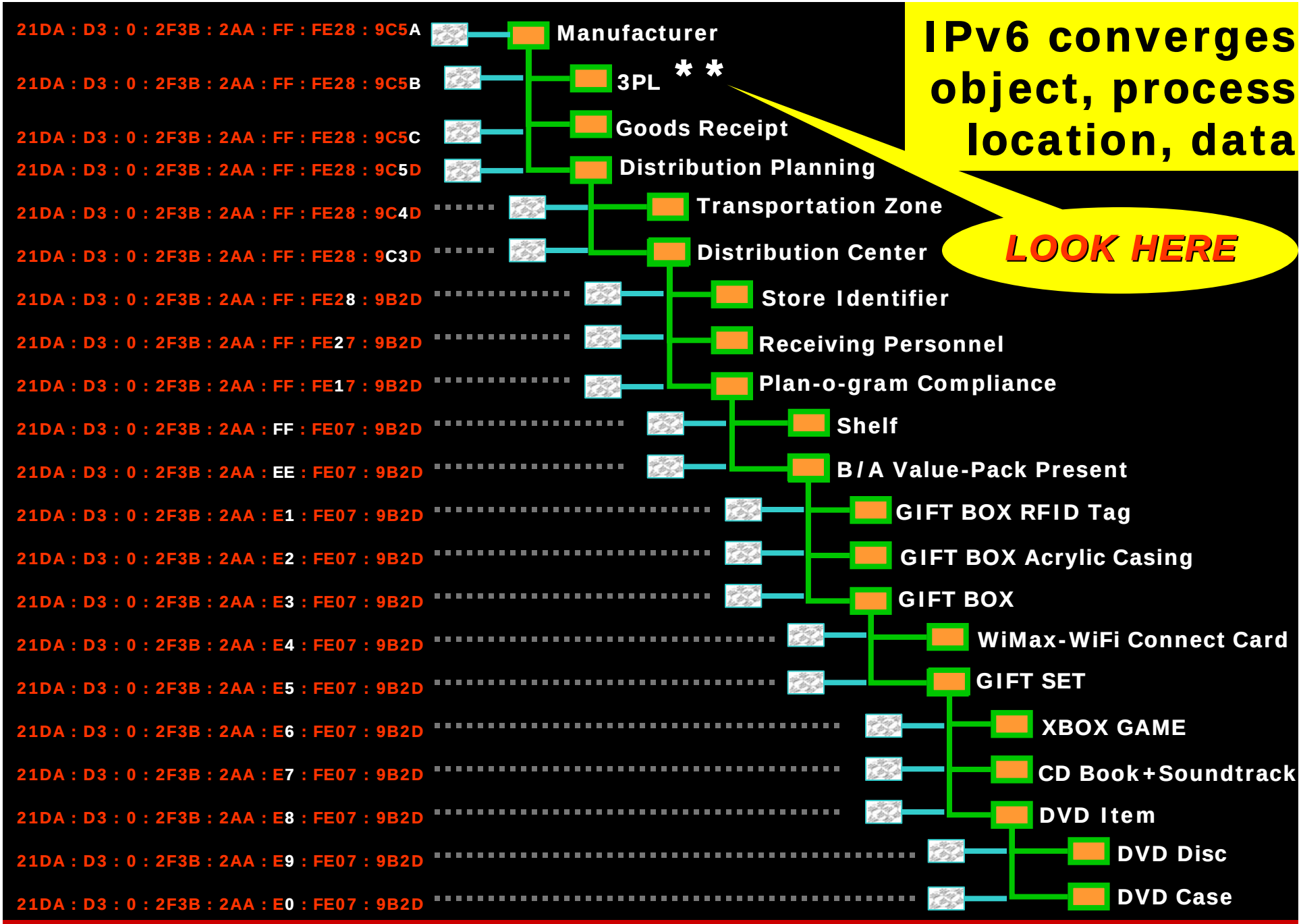


Single host to multi receiver.
Defined devices listen for ☑ multicast packets.

ANYCAST



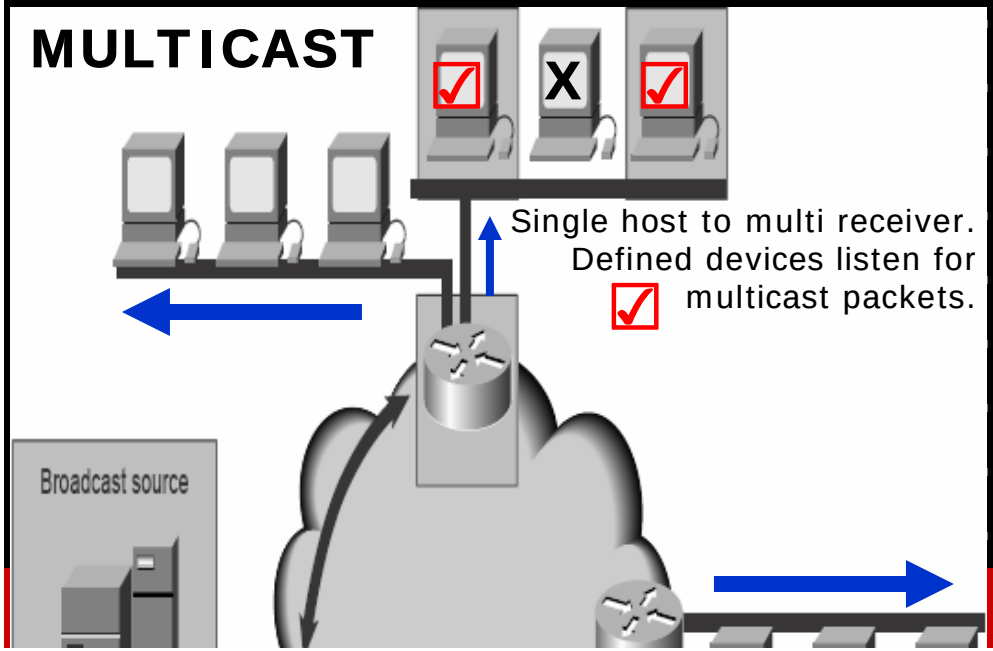
Single sender to address list.
Packets to specified interfaces including nodes ◘ & routers.


21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A
Manufacturer
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B
3PL
* *
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C
Goods Receipt
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D
Distribution Planning
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D
Transportation Zone
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D
Distribution Center
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D
Store Identifier
21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D
Receiving Personnel
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D
Plan-o-gram Compliance
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
Shelf
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
B/A Value-Pack Present
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D
GIFT BOX RFID Tag
21DA : D3 : 0 : 2F3B : 2AA : E2 : FE07 : 9B2D
GIFT BOX Acrylic Casing
21DA : D3 : 0 : 2F3B : 2AA : E3 : FE07 : 9B2D
GIFT BOX
21DA : D3 : 0 : 2F3B : 2AA : E4 : FE07 : 9B2D
WiMax-WiFi Connect Card
21DA : D3 : 0 : 2F3B : 2AA : E5 : FE07 : 9B2D
GIFT SET
21DA : D3 : 0 : 2F3B : 2AA : E6 : FE07 : 9B2D
XBOX GAME
21DA : D3 : 0 : 2F3B : 2AA : E7 : FE07 : 9B2D
CD Book+Soundtrack
21DA : D3 : 0 : 2F3B : 2AA : E8 : FE07 : 9B2D
DVD Item
21DA : D3 : 0 : 2F3B : 2AA : E9 : FE07 : 9B2D
DVD Disc
21DA : D3 : 0 : 2F3B : 2AA : E0 : FE07 : 9B2D
DVD Case
IPv6 converges object, process location, data
LOOK HERE

IPv6 converges object, process location, data

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A — Manufacturer
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B — 3PL * *
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C — Goods Receipt
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D — Distribution Planning
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D — Transportation Zone
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D — Distribution Center
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D — Store Identifier
21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D — Receiving Personnel
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D — Plan-o-gram Compliance
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D — Shelf
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D — B/A Value-Pack Present
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D — GIFT BOX RFID Tag
GIFT BOX Acrylic Casing
GIFT BOX
WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case

MULTICAST



Single host to multi receiver.
Defined devices listen for
multicast packets.

IPv6 converges object, process location, data

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A — Manufacturer

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B — 3PL * *

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C — Goods Receipt

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D — Distribution Planning

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D — Transportation Zone

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D — Distribution Center

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D — Store Identifier

21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D — Receiving Personnel

21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D — Plan-o-gram Compliance

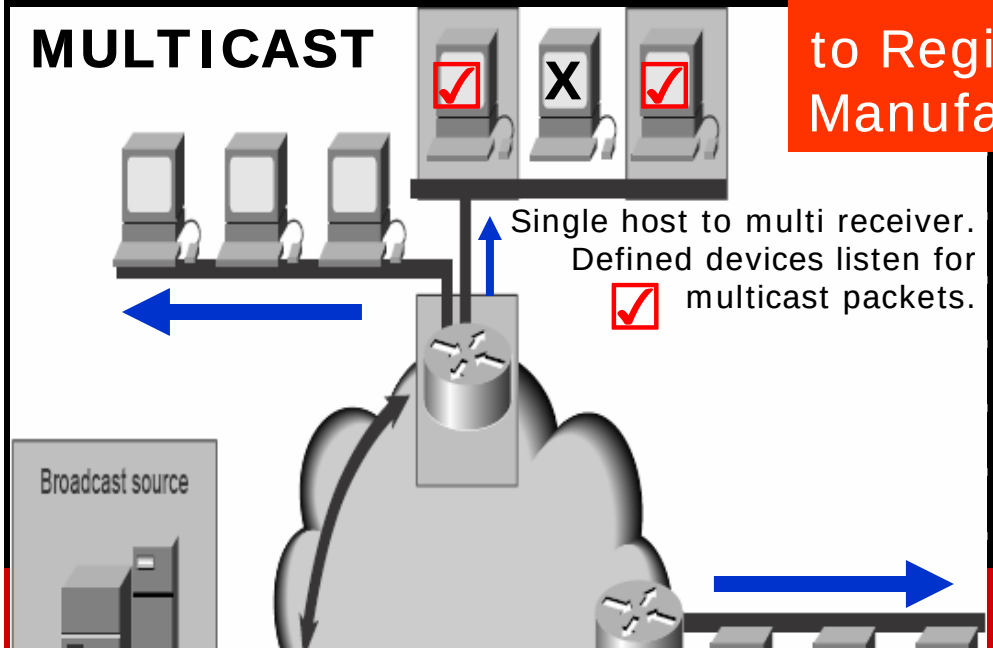
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D — Shelf

21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

** 3PL transmits
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C50
to Regional Distribution Center & Store
Manufacturer is automatically updated.

MULTICAST



WiMax-WiFi Connect Card

GIFT SET

XBOX GAME

CD Book+Soundtrack

DVD Item

DVD Disc

DVD Case

IPv6 converges object, process location, data

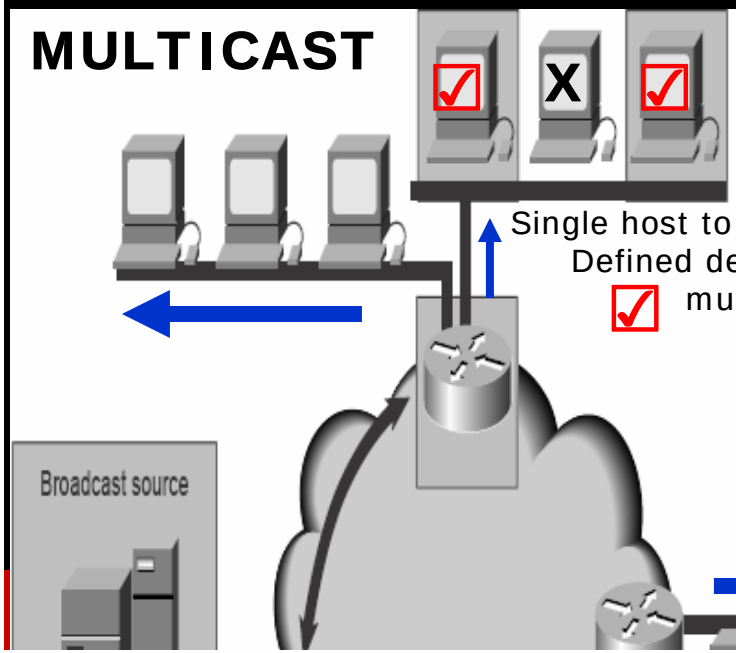
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

Manufacturer
3PL * *
Goods Receipt
Distribution Planning
Personnel
Plan-o-gram
Appliance
Shelf

Id transmitted is different than id linked.

** 3PL transmits
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C50
to Regional Distribution Center & Store Manufacturer is automatically updated.

MULTICAST



Single host to multi receiver.
Defined devices listen for multicast packets.

WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case

IPv6 converges object, process location, data

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

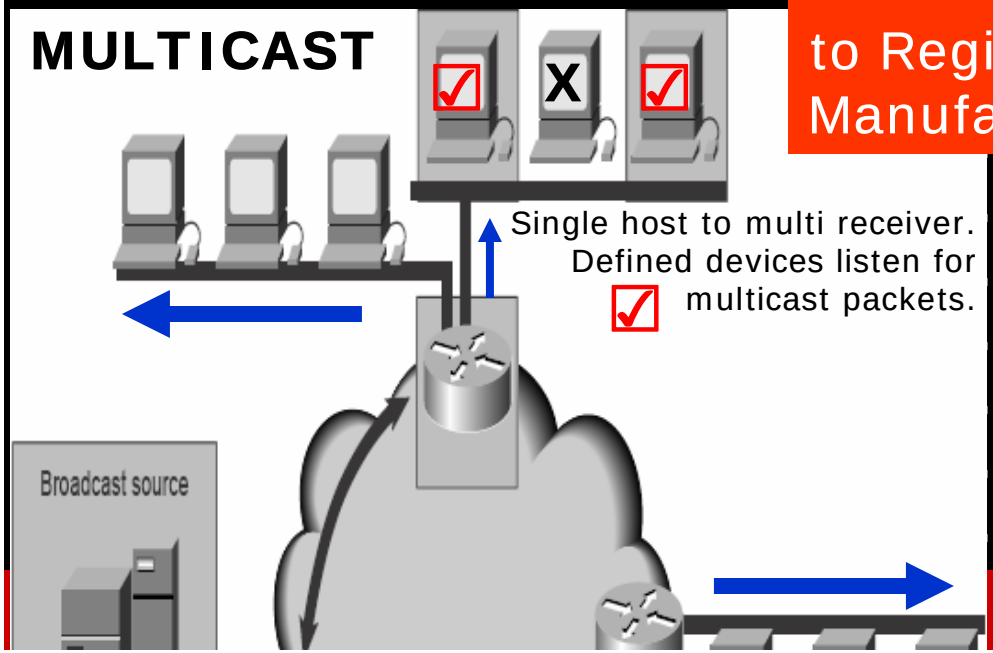
Manufacturer
3PL * *
Goods Receipt
Distribution Planning
Personnel
Plan-o-gram
Appliance
Shelf

Id transmitted is different than id linked.

Why?

** 3PL transmits
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C50
to Regional Distribution Center & Store Manufacturer is automatically updated.

MULTICAST



Single host to multi receiver.
Defined devices listen for ☑ multicast packets.

WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case

IPv6 converges object, process location, data

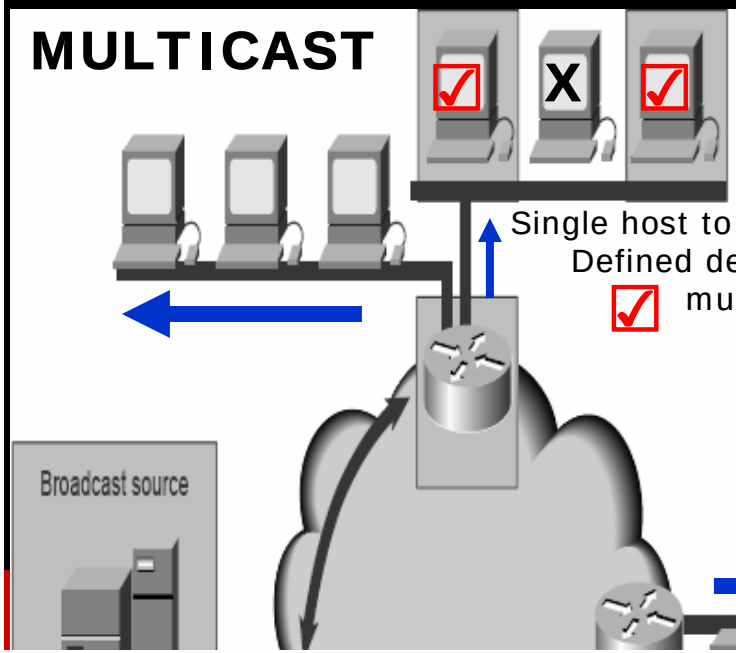
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D
21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

Manufacturer
3PL * *
Goods Receipt
Distribution Planning
Personnel
Plan-o-gram
Appliance
Shelf

Id transmitted is id shown + arrival times.

** 3PL transmits
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C50
to Regional Distribution Center & Store Manufacturer is automatically updated.

MULTICAST



Single host to multi receiver.
Defined devices listen for ☑ multicast packets.

WiMax-WiFi Connect Card
GIFT SET
XBOX GAME
CD Book+Soundtrack
DVD Item
DVD Disc
DVD Case

IPv6 converges object, process location, data

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5A — Manufacturer

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5B — 3PL * *

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5C — Goods Receipt

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C5D — Distribution Planning

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C4D — Transportation Zone

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C3D — Distribution Center

21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9B2D — Store Identifier

21DA : D3 : 0 : 2F3B : 2AA : FF : FE27 : 9B2D — Receiving Personnel

21DA : D3 : 0 : 2F3B : 2AA : FF : FE17 : 9B2D — Plan-o-gram Compliance

21DA : D3 : 0 : 2F3B : 2AA : FF : FE07 : 9B2D — Shelf

21DA : D3 : 0 : 2F3B : 2AA : EE : FE07 : 9B2D

21DA : D3 : 0 : 2F3B : 2AA : E1 : FE07 : 9B2D

** 3PL transmits
21DA : D3 : 0 : 2F3B : 2AA : FF : FE28 : 9C50
to Regional Distribution Center & Store
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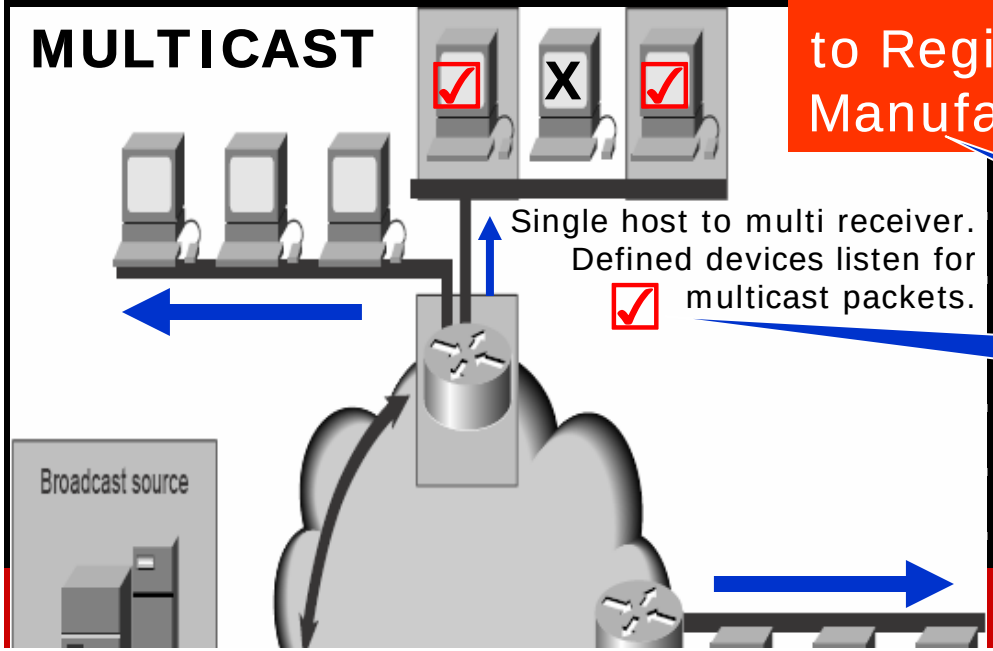
MULTICAST



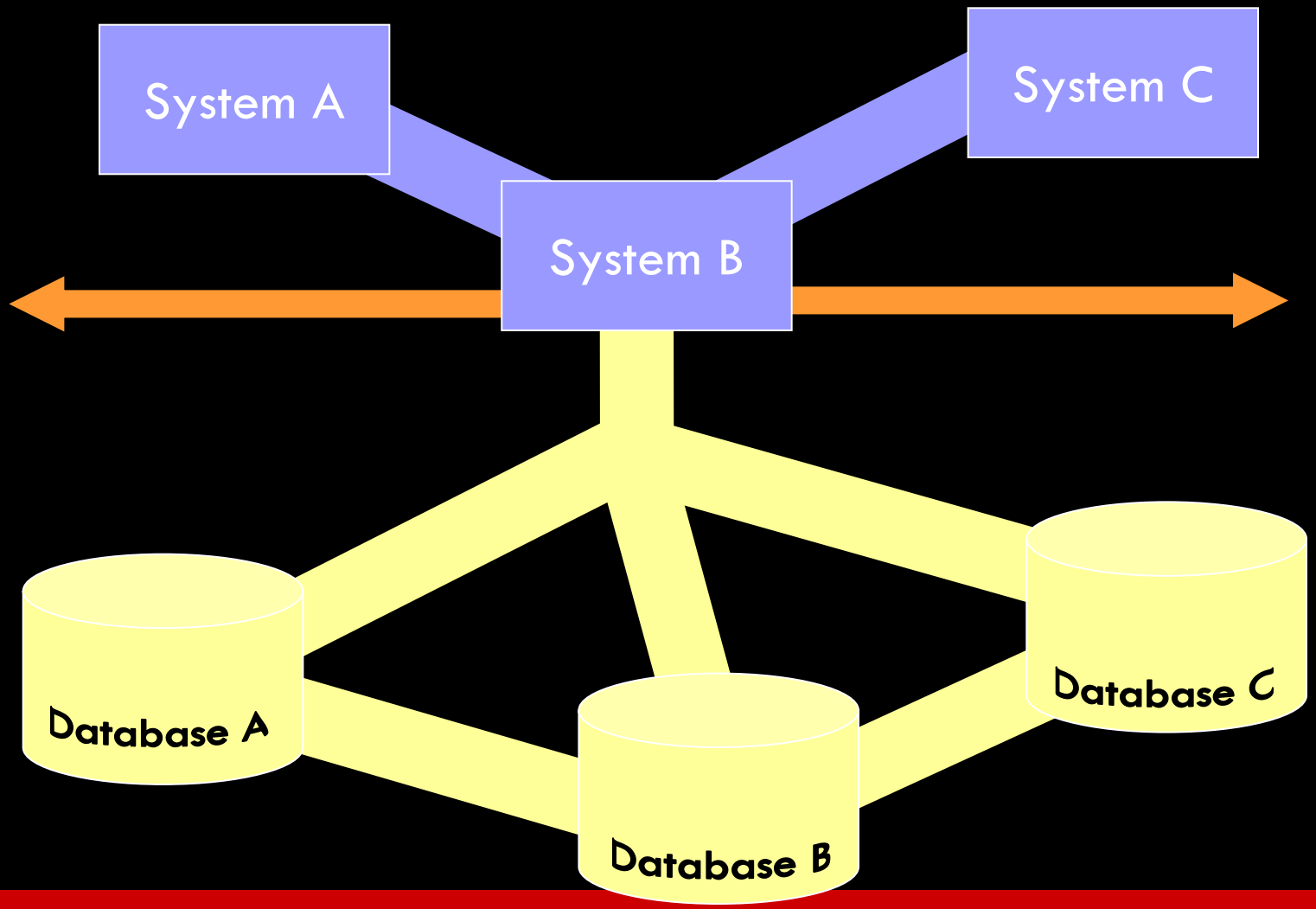
GIFT SET

DVD Case

Manufacturer is a “defined device” process.

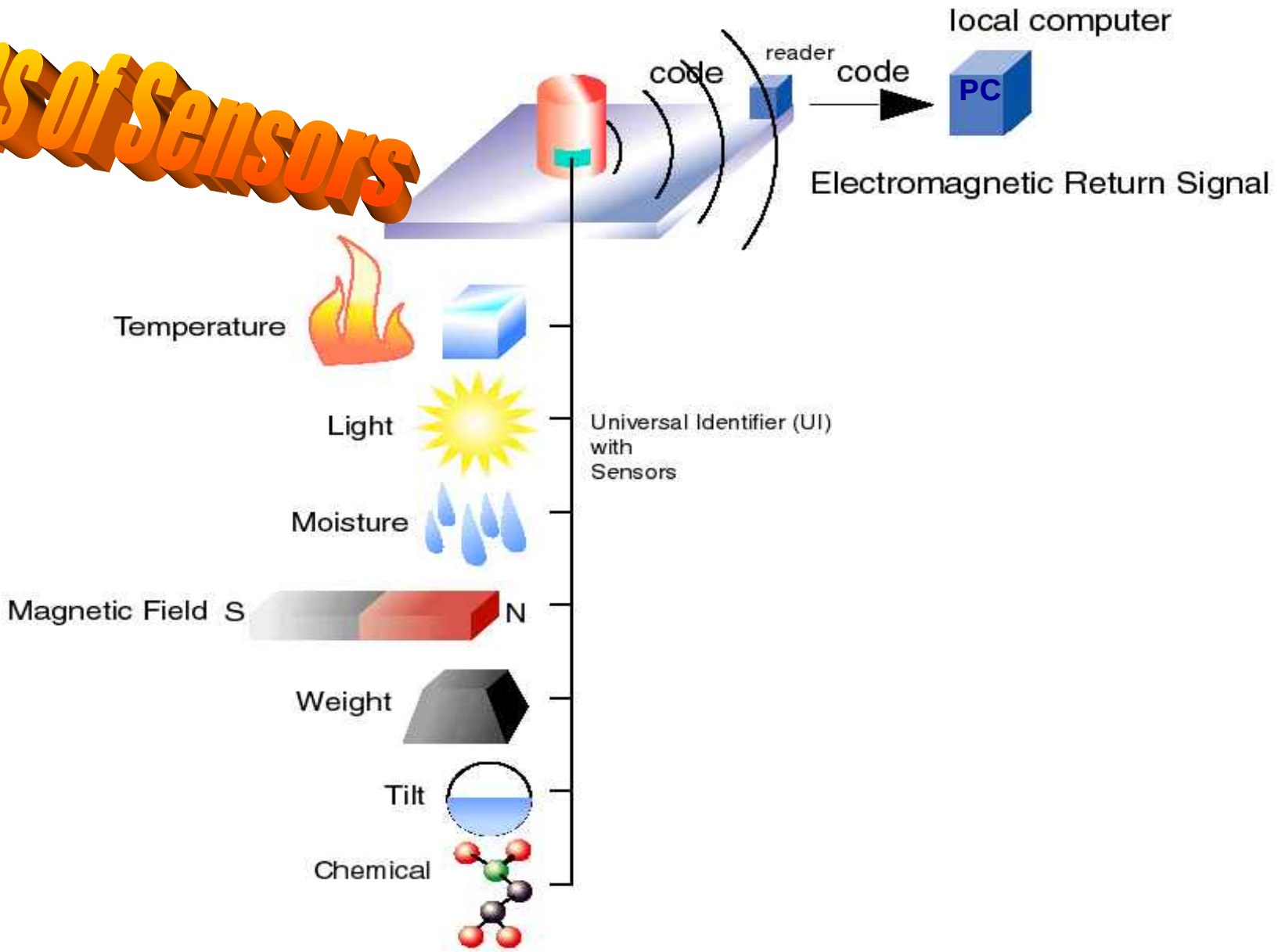
Benefit from IPv6 Format with Data Routing

Related Information Integration and Systems Interoperability



Data

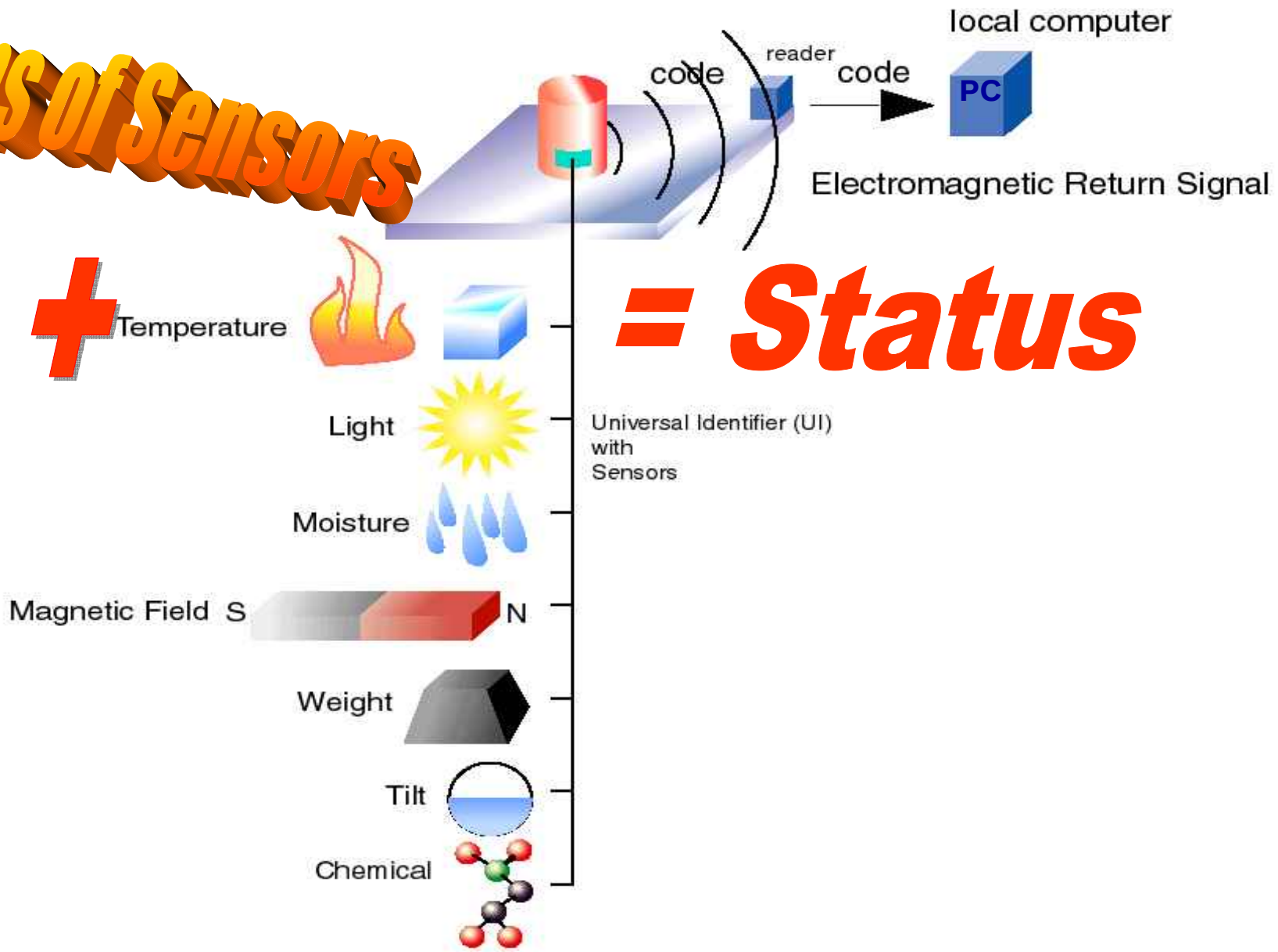
Trillions of Sensors



Process, Data, Information

Trillions of Sensors

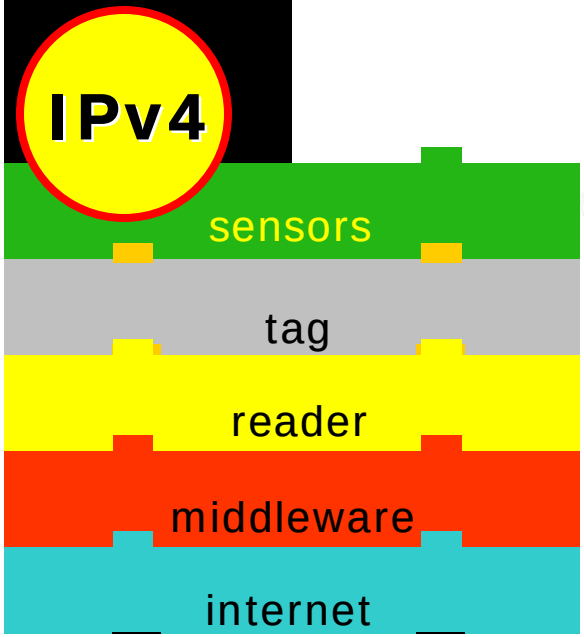
ID + = Status

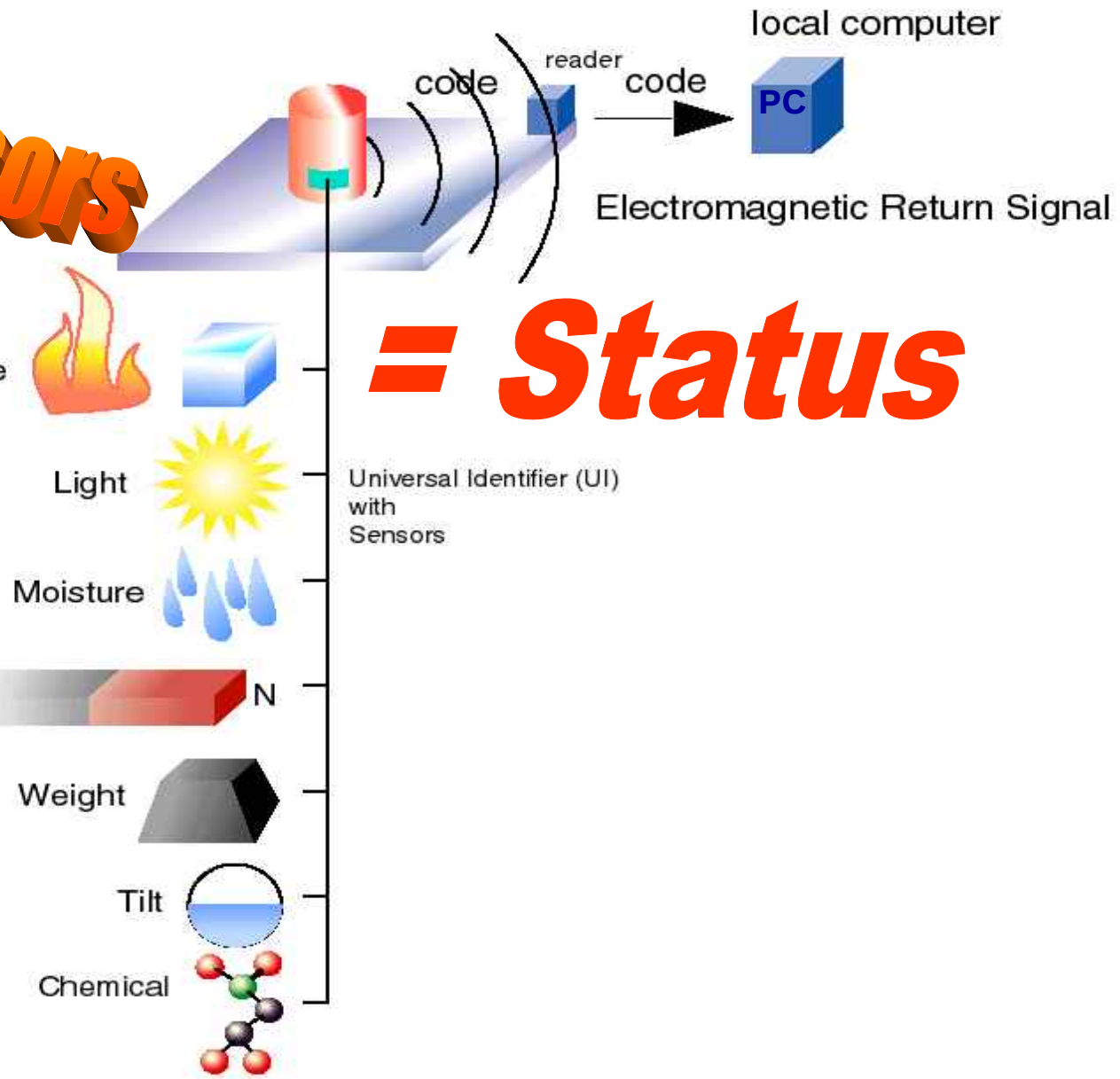


Process, Data, Information

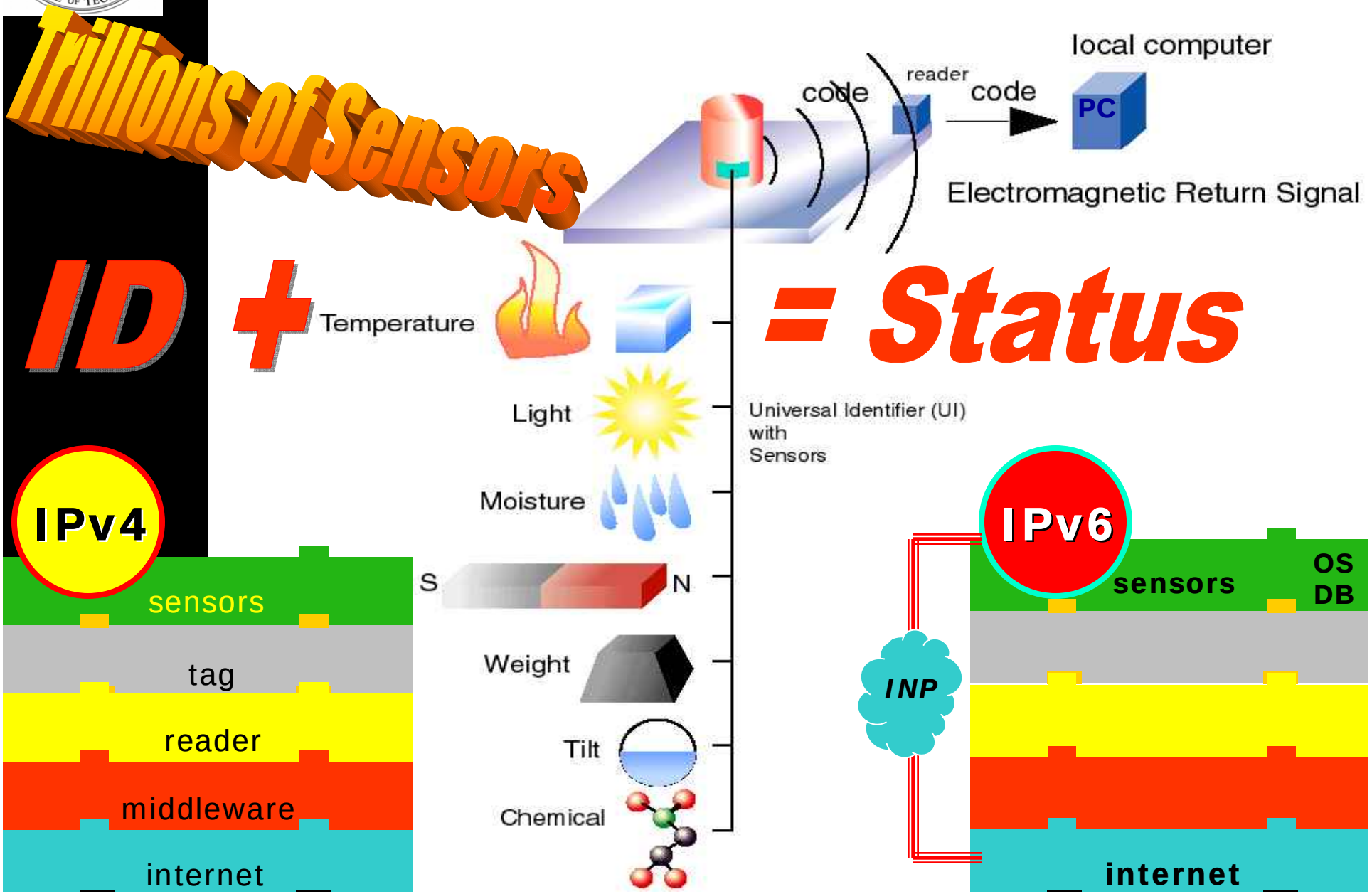
Trillions of Sensors

ID + = Status

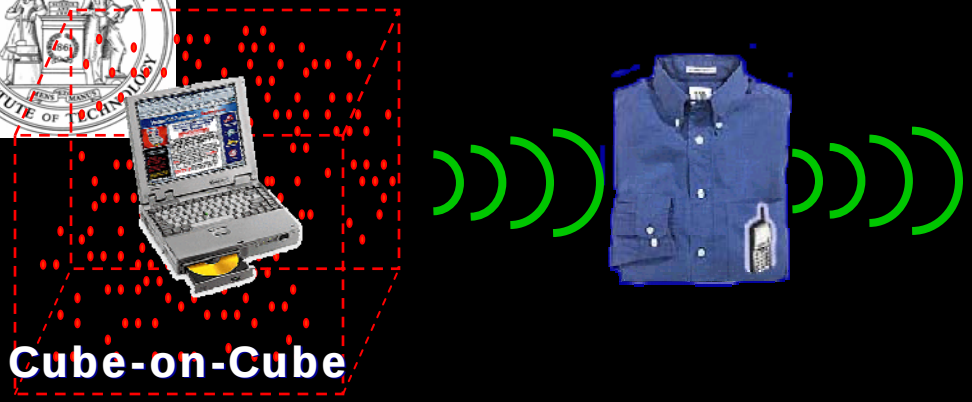




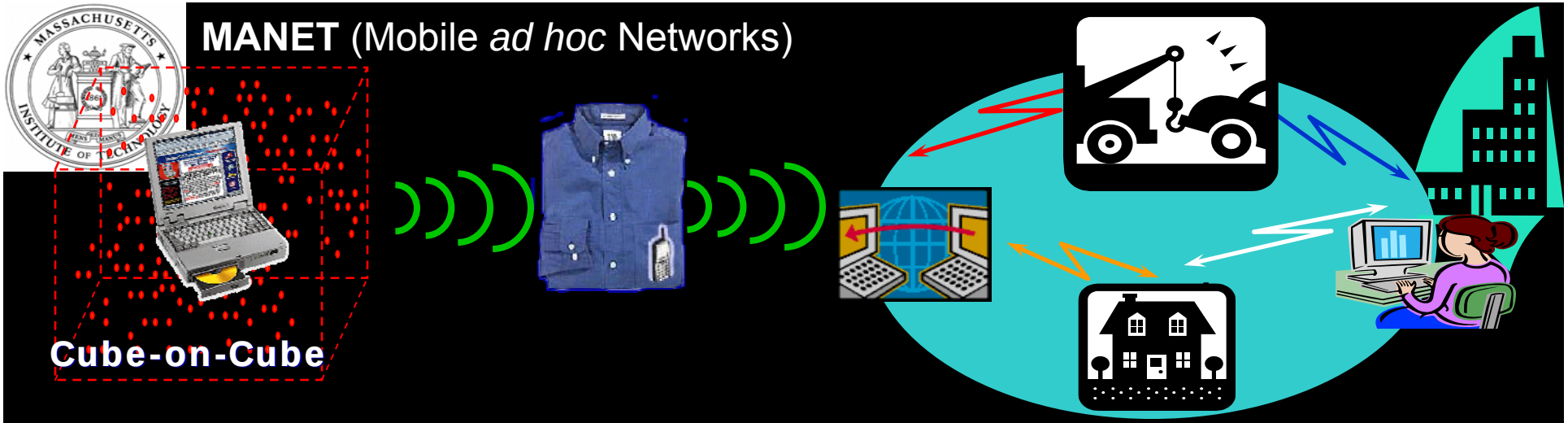
Process, Data, Identity & Information



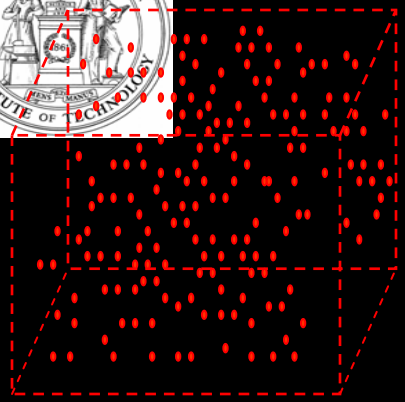
MANET (Mobile *ad hoc* Networks)

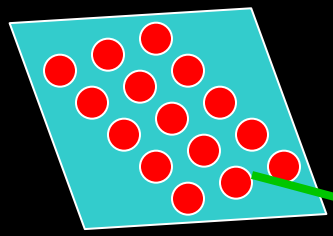


MANET (Mobile *ad hoc* Networks)



MANET (Mobile *ad hoc* Networks)

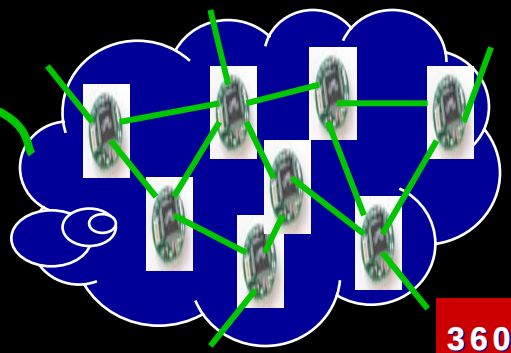




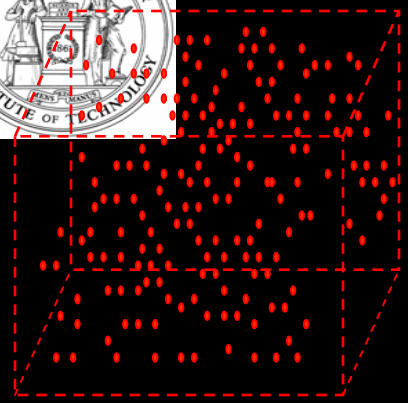
1 mm

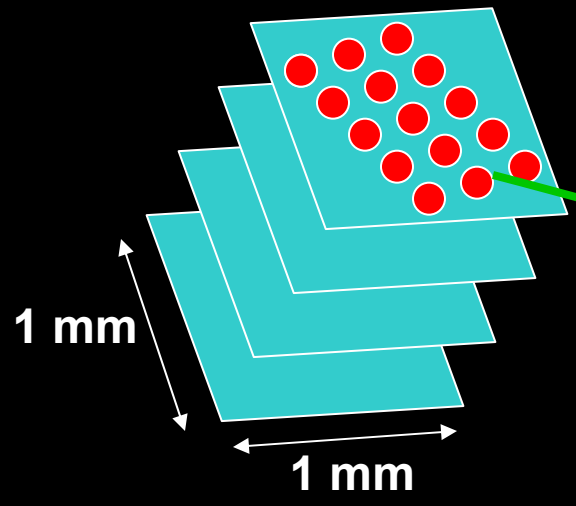
1 mm

60 billion interfaces
per square mm
requires unique id



MANET (Mobile *ad hoc* Networks)





60 billion interfaces
per square mm
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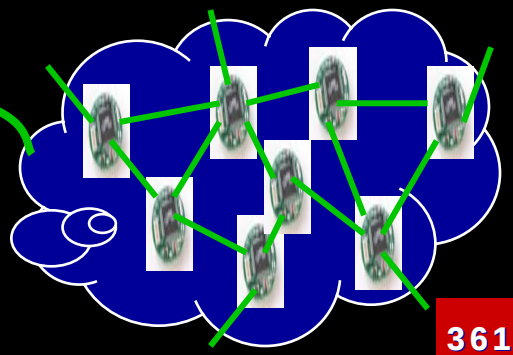
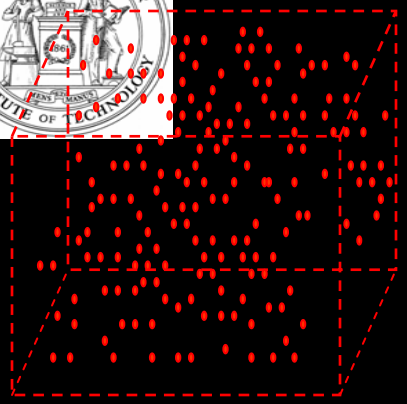
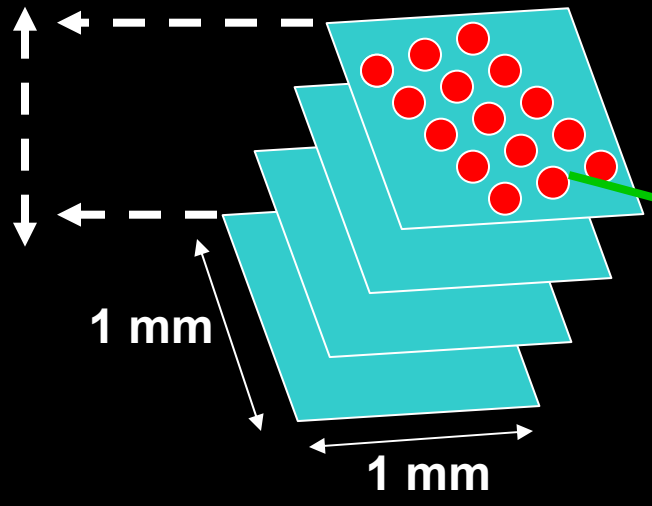


MANET (Mobile *ad hoc* Networks)



Layer is 100 km deep
or 1,000,000,000 mm



60 billion interfaces
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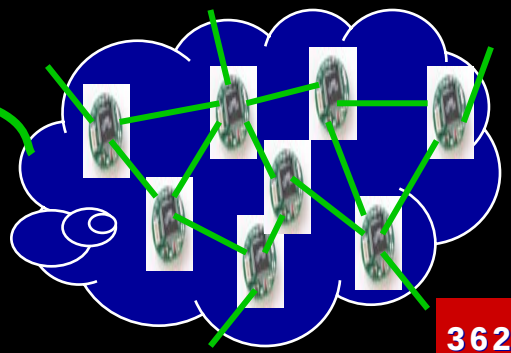
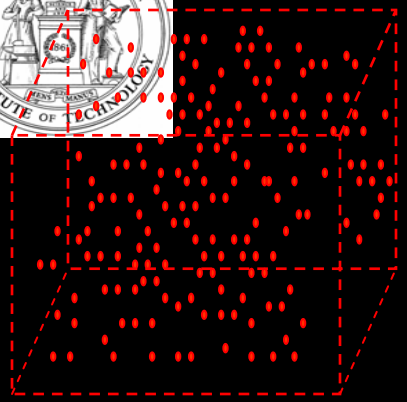


Examples of Mobile *ad hoc* Networks: Automobile Industry & Civil Engineering



Layer is 100 km deep
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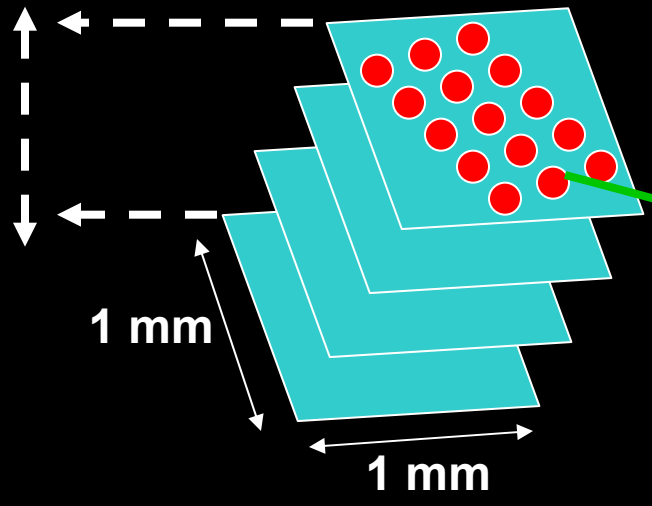
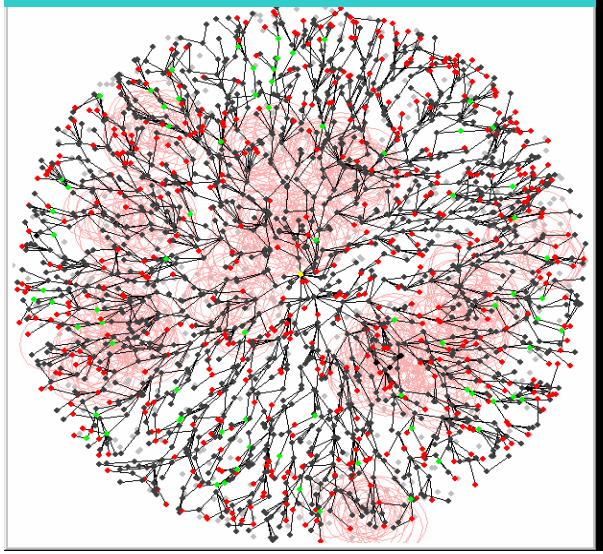
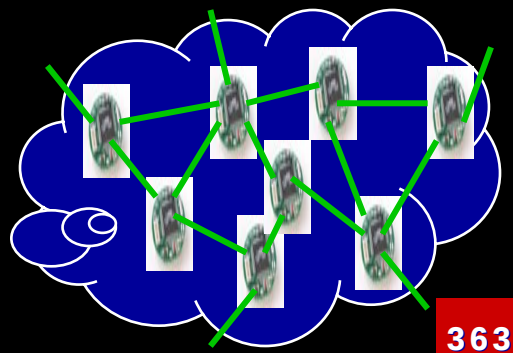


60 billion interfaces
per square mm
with unique IPv6 id

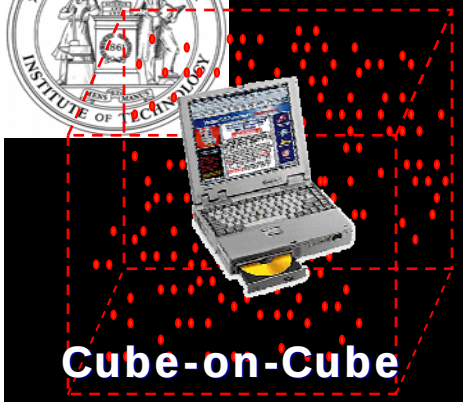
DEEPLY EMBEDDED **SENSOR NETWORKS**

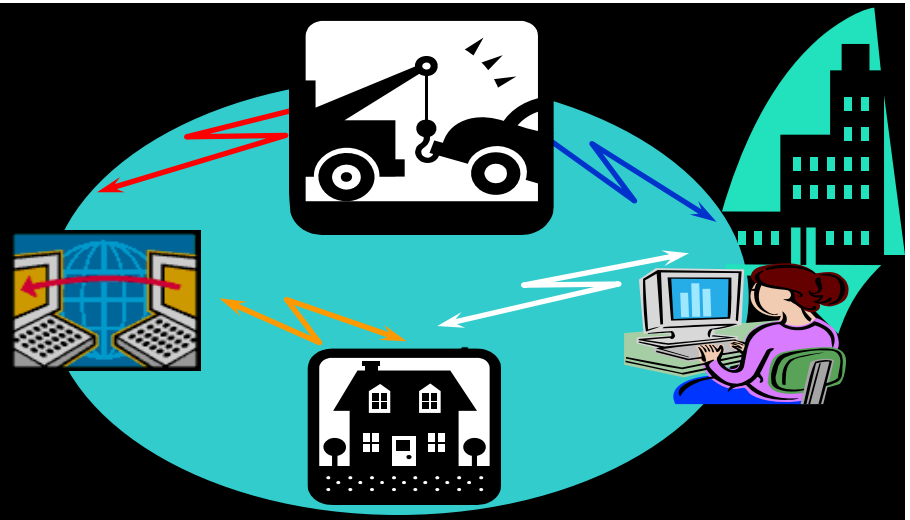


Automobile Building

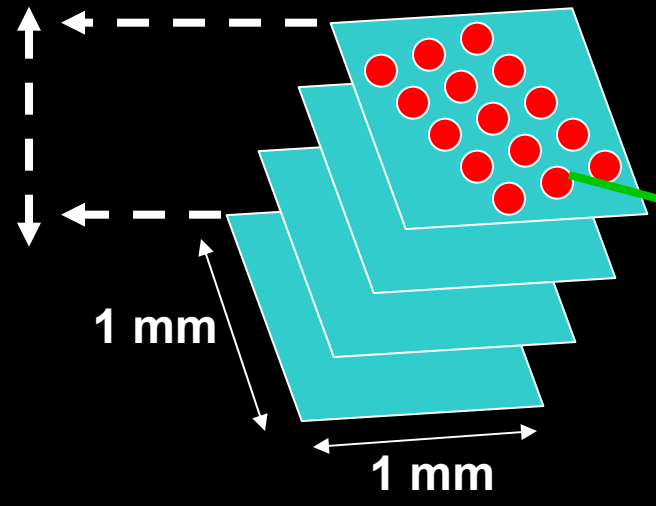


MANET (Mobile *ad hoc* Networks)



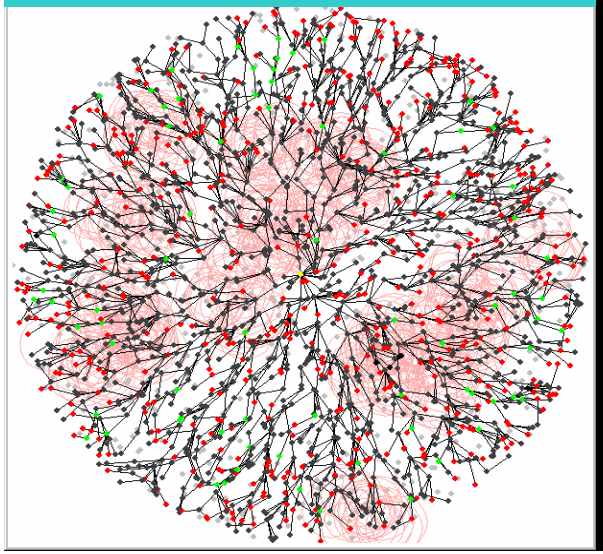


Layer is 100 km deep
or 1,000,000,000 mm

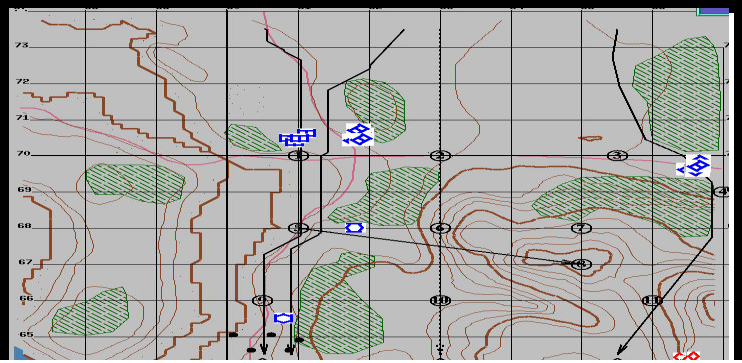


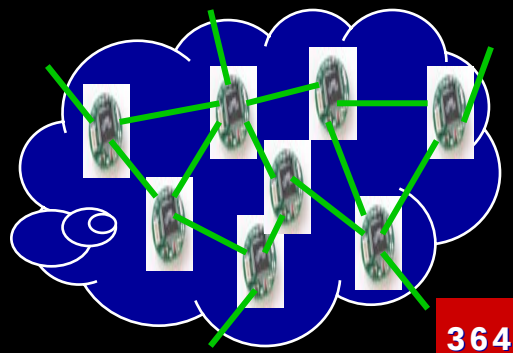
60 billion interfaces
per square mm Earth
with unique IPv6 id

DEEPLY EMBEDDED **SENSOR NETWORKS**

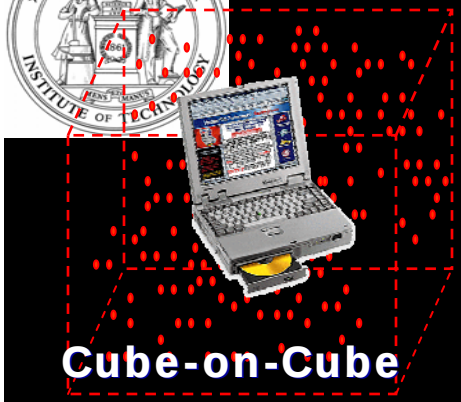


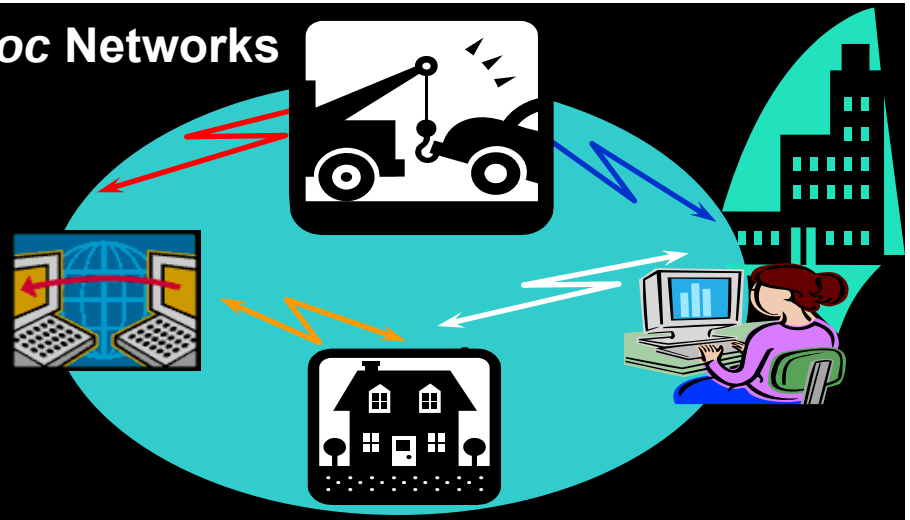
Earth's Surface



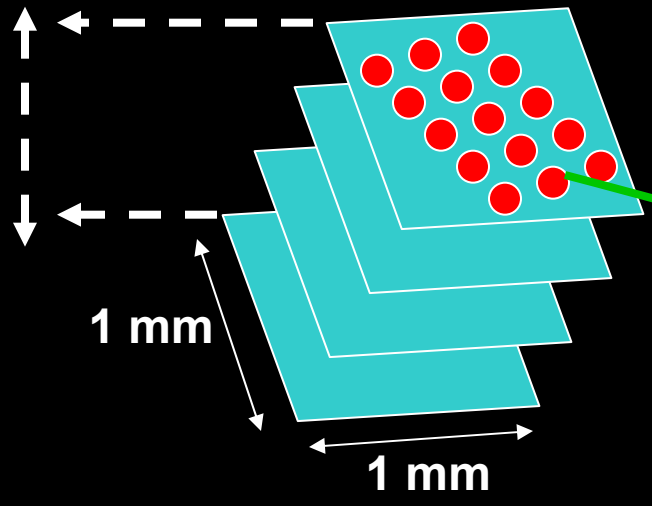


TRANSPORTATION = Mobile *ad hoc* Networks



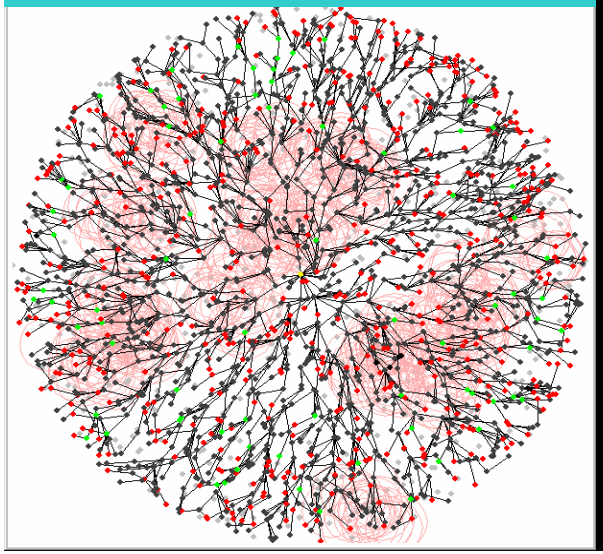


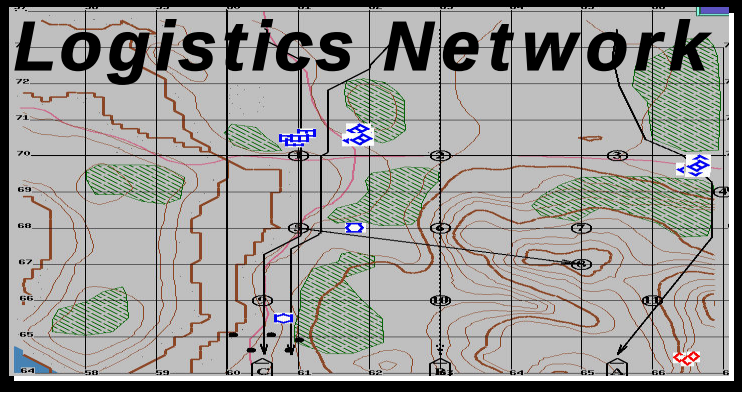
Layer is 100 km deep
or 1,000,000,000 mm

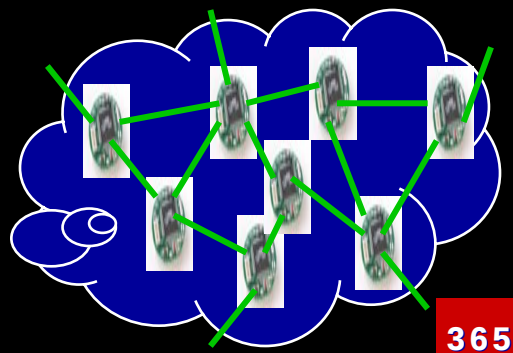


60 billion interfaces
per square mm Earth
with unique IPv6 id

DEEPLY EMBEDDED **SENSOR NETWORKS**







MANET

SCM Logistics Transportation

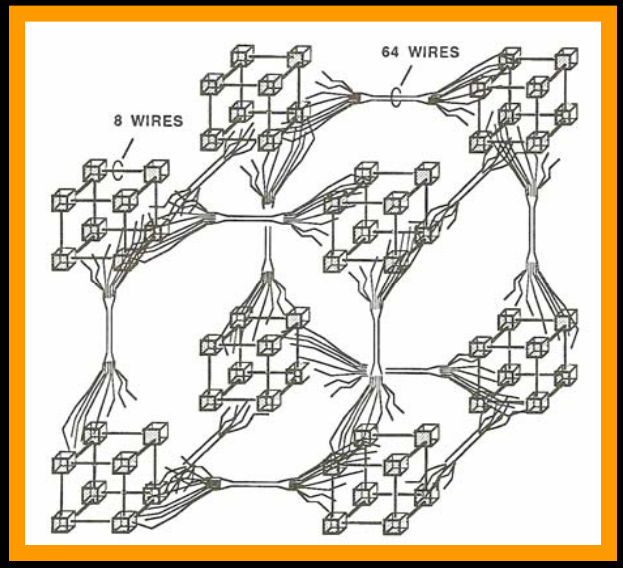
- Manufacturer
  - 3PL
  - Goods Receipt
  - Distribution Planning
    - Transportation Zone
    - Distribution Center
      - Store Identifier
      - Receiving Personnel
      - Plan-o-gram Compliance
        - Shelf
        - B/A Value-Pack Present
          - GIFT BOX RFID Tag
          - GIFT BOX Acrylic Casing
          - GIFT BOX
            - WiMax-WiFi Connect Card
            - GIFT SET
              - XBOX GAME
              - CD Book+Soundtrack
              - DVD Item
                - DVD Disc
                - DVD Case

Billions of Objects

Trillions of Processes

Octillions of Identities

Exabytes of Data



End of the Information Age

Making Sense of Data

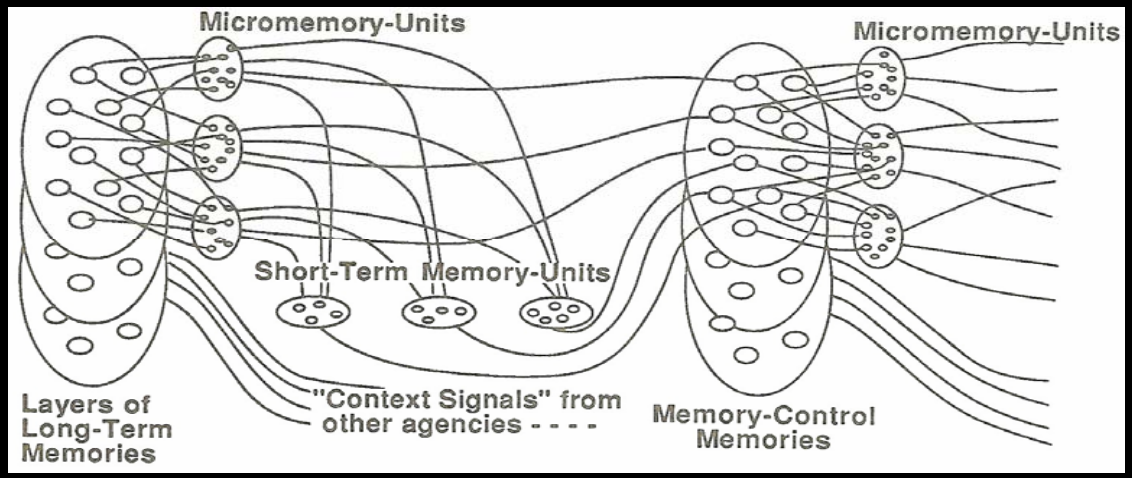
End of the Information Age

Welcome to the

SYSTEMS AGE

Source: From Neurons to the Brain

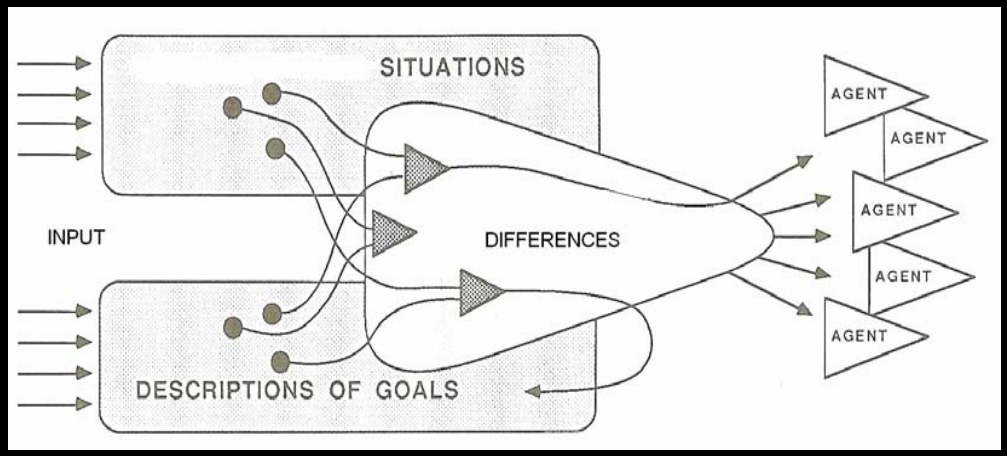
Making Sense of Data: Introducing Elementary AI

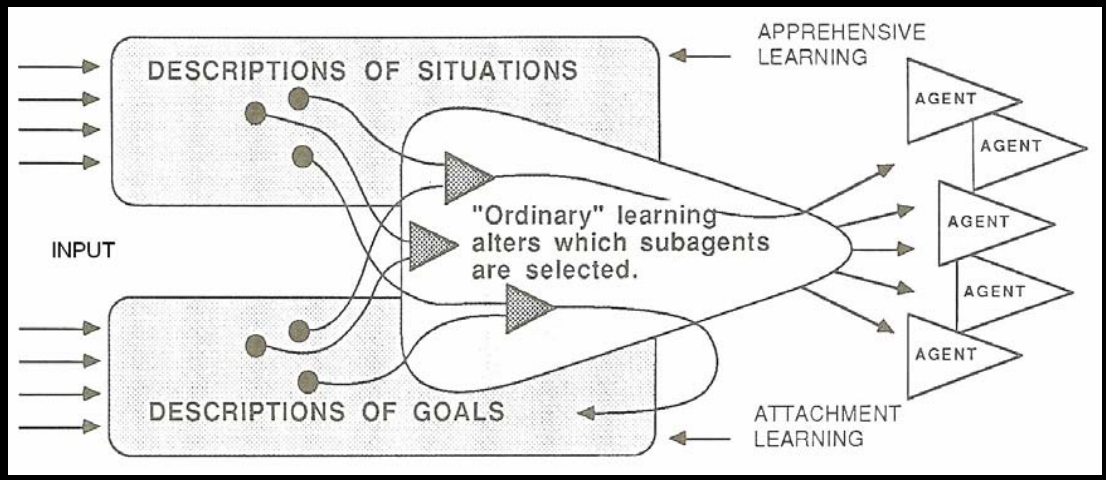


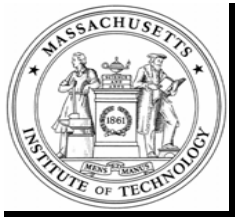
Basic Neural Circuits

Source: Marvin Minsky, AI Lab, MIT

Difference Engines (1950)

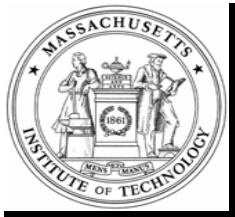




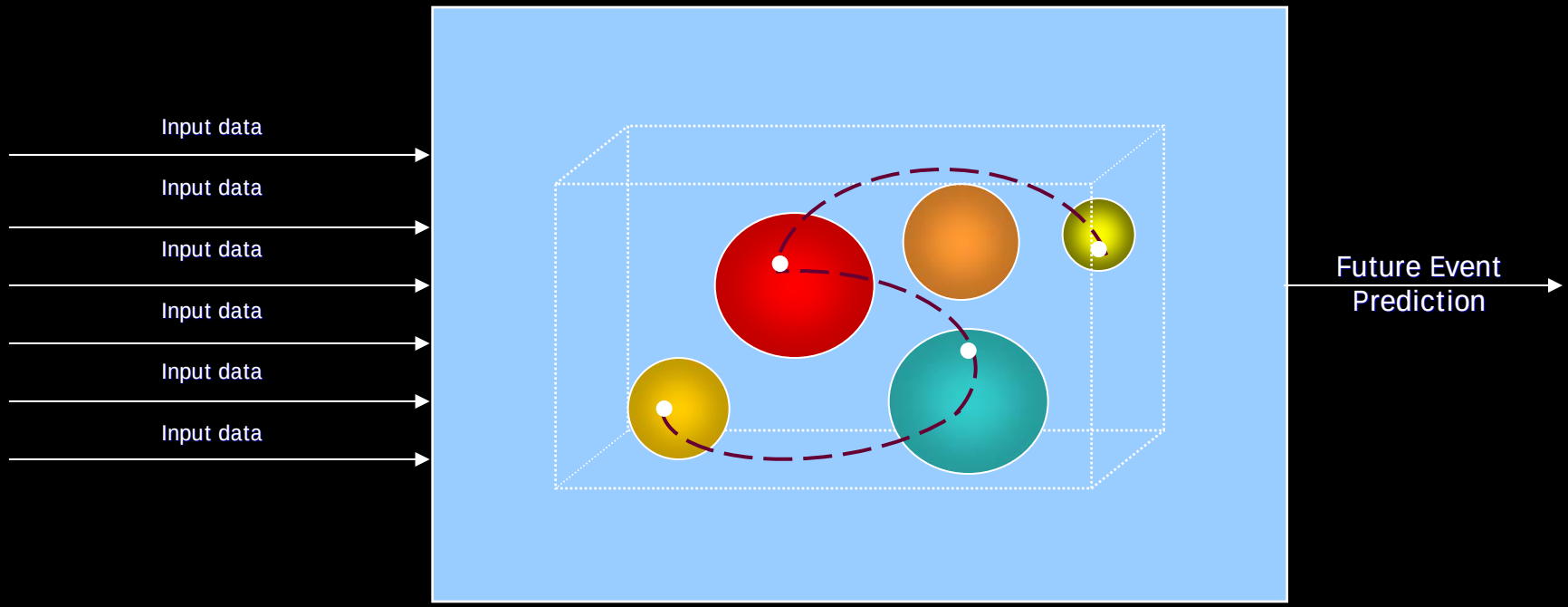


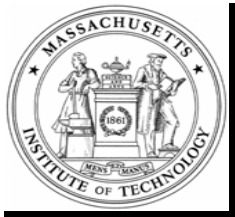
Rule Based Applications

BANKING/ FINANCE	INSURANCE	MANUFACTURING	GOVERNMENT	OTHER INDUSTRIES
Online Mortgage Underwriting	Point-of-Sale Underwriting	Parts Selection	Welfare Eligibility Determination	Transportation
Credit Scoring	Claims Processing	Order Configuration	Regulatory Compliance	Retail
Portfolio Management	Renewal Processing	Production Planning/Routing	Tax Assessment	Petroleum/ Oil & Gas
Cross Selling	Intelligent Policy Configuration and Pricing	Production Scheduling	Entitlements and Benefits Determination	Health Care
Fraud Detection	Eligibility Determination	Maintenance and Labor Scheduling	Pension Plan Forecasting	Telecom
Overdraft Authorization	Cross Selling	Material Safety Data Sheets	Worker's Compensation Claims	Pharmaceutical
SEC Regulatory Compliance	Fraud Detection	Distribution Management		Utilities
Risk Management				

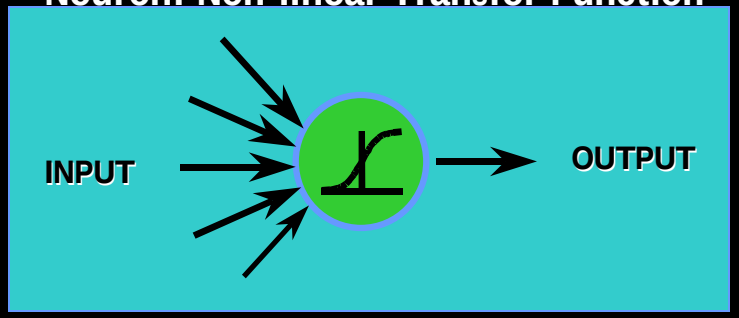


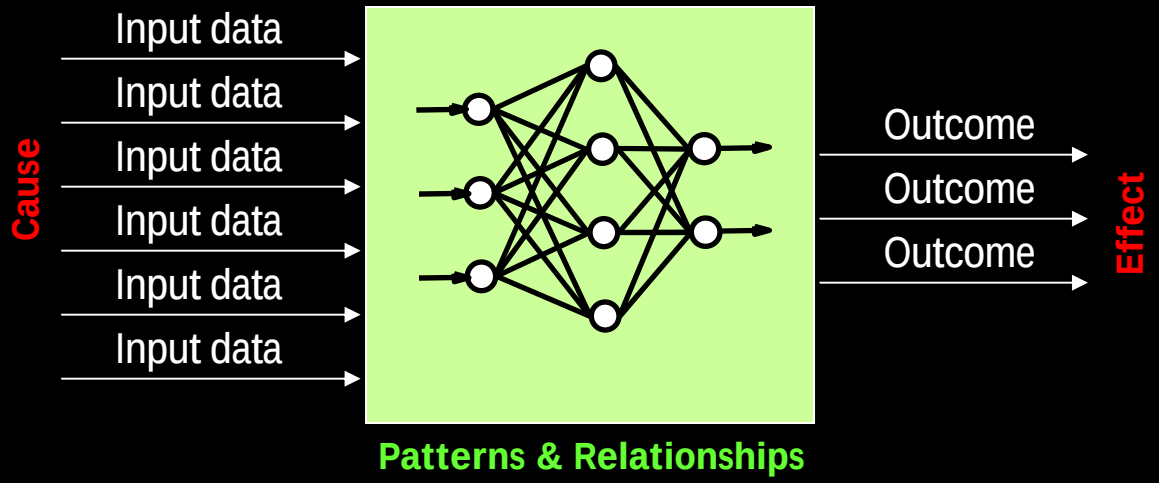
State Transitioning

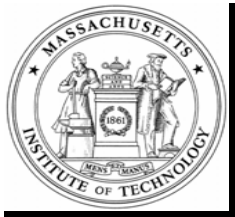




Neuron: Non-linear Transfer Function

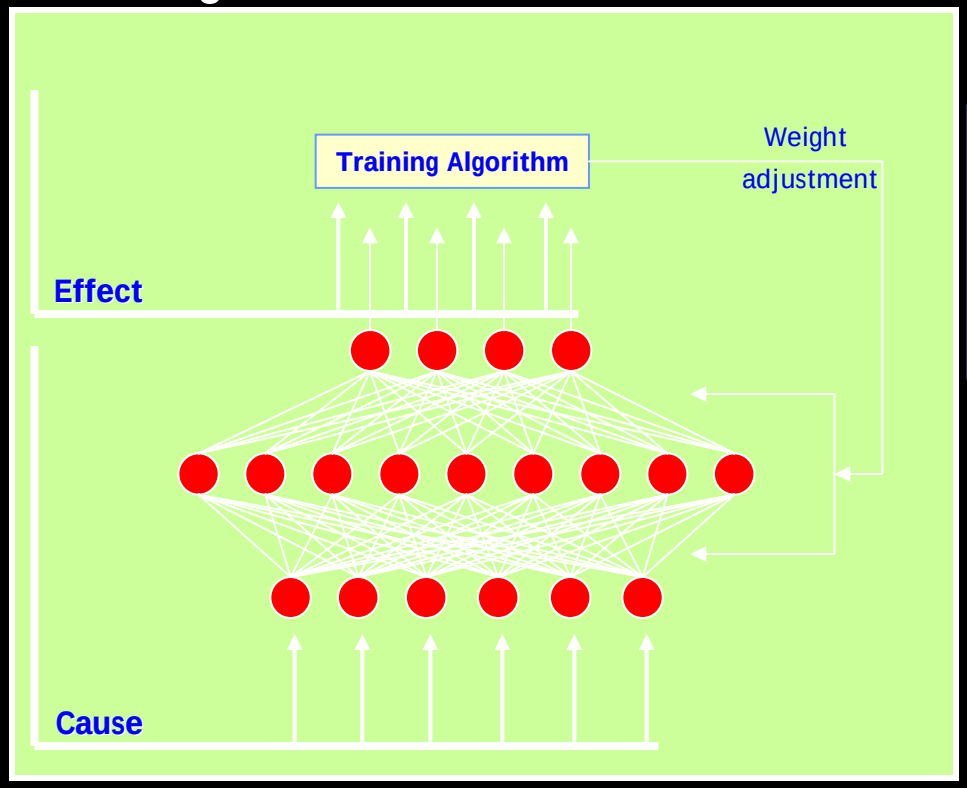






Training

Input data
Input data
Input data
Input data
Input data
Input data

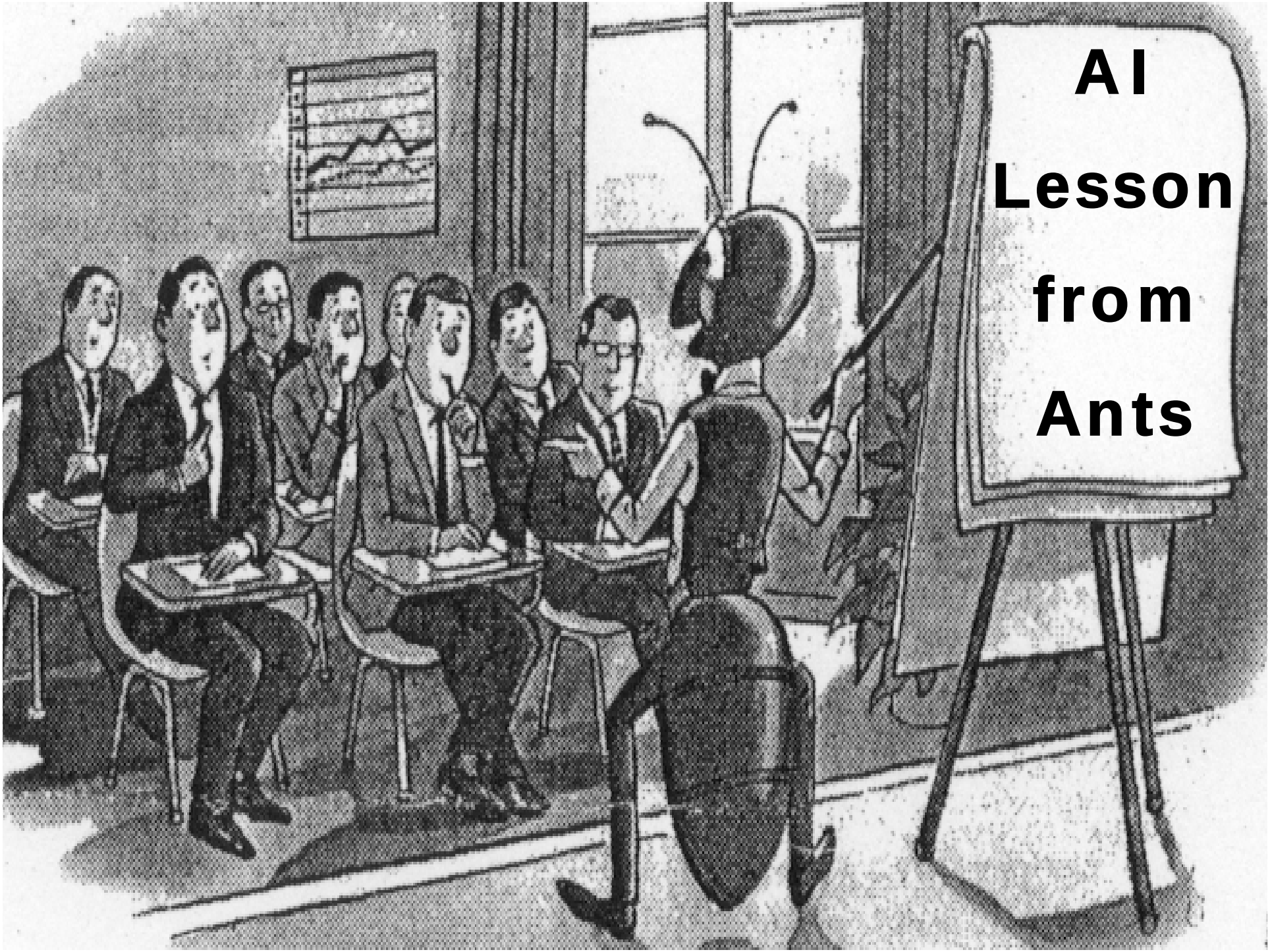


Prediction

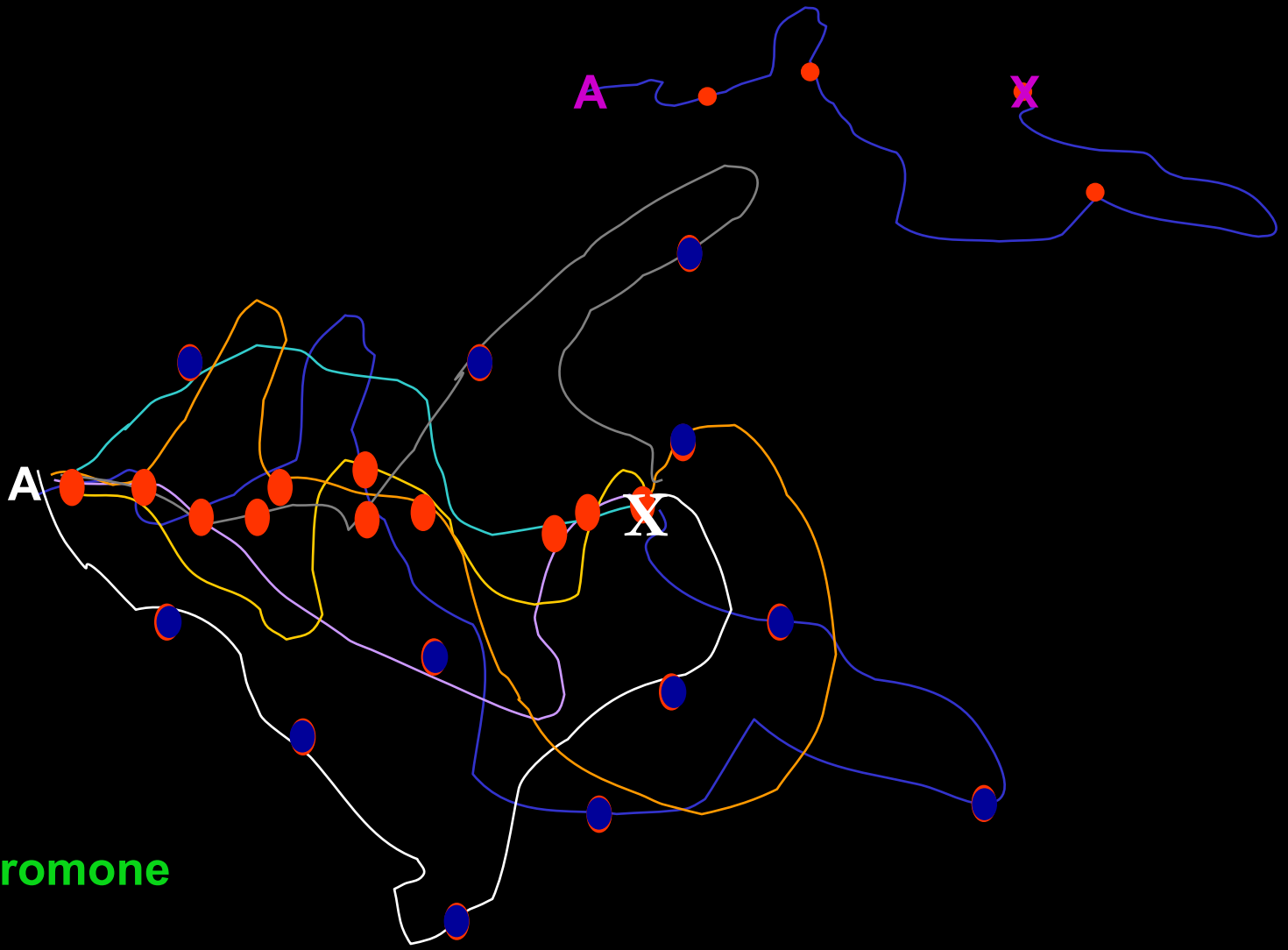
- Anticipate component failure
- Replace part prior to failure
- Preventive maintenance plan
- Improve customer response
- Reduce repair cycles
- Support performance metrics
- Better identify causes of problems
- Learn to adapt to the environment

Outcome
Outcome
Outcome
Outcome
Outcome
Outcome


May I help?

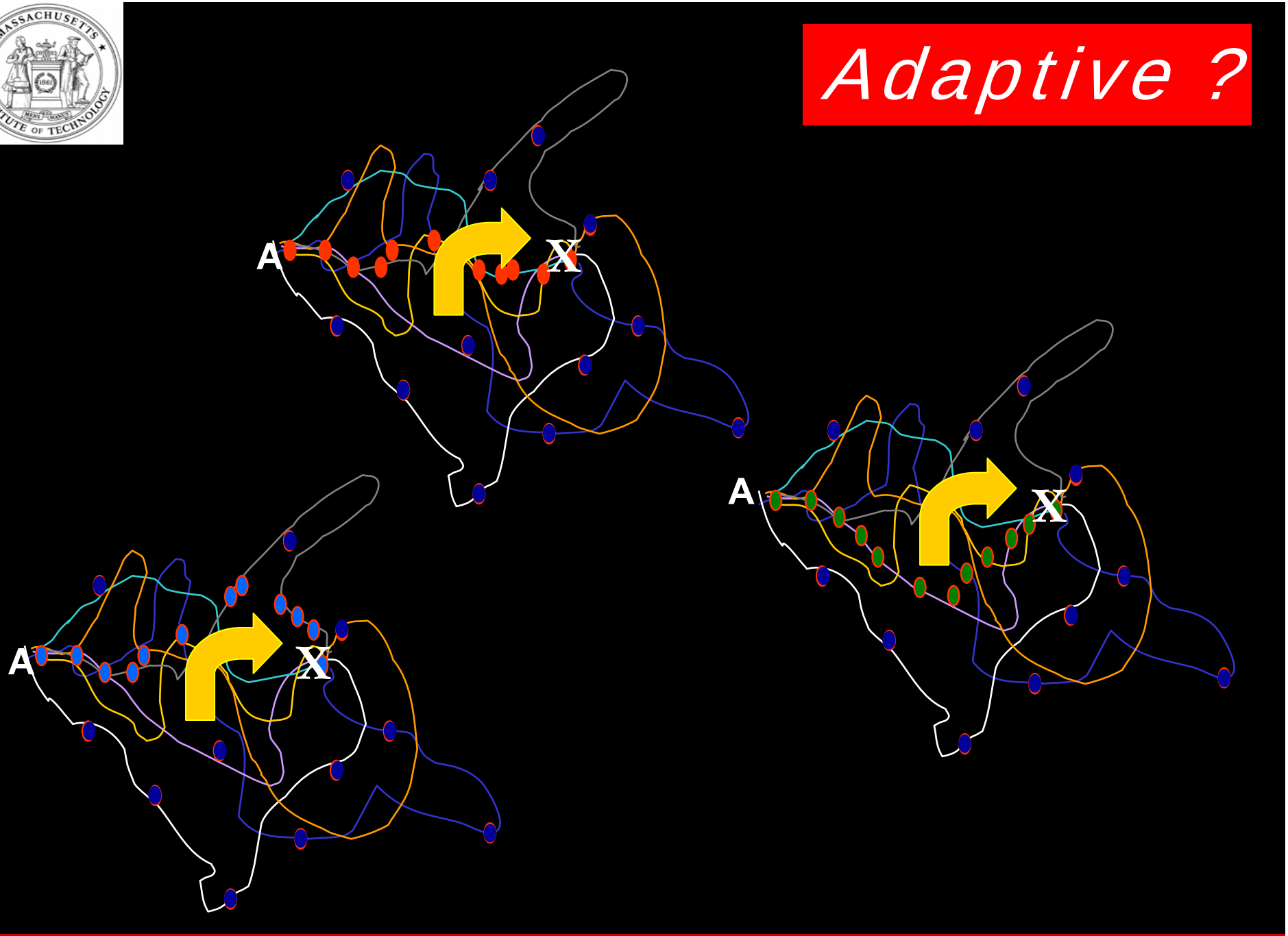

AI
Lesson
from
Ants

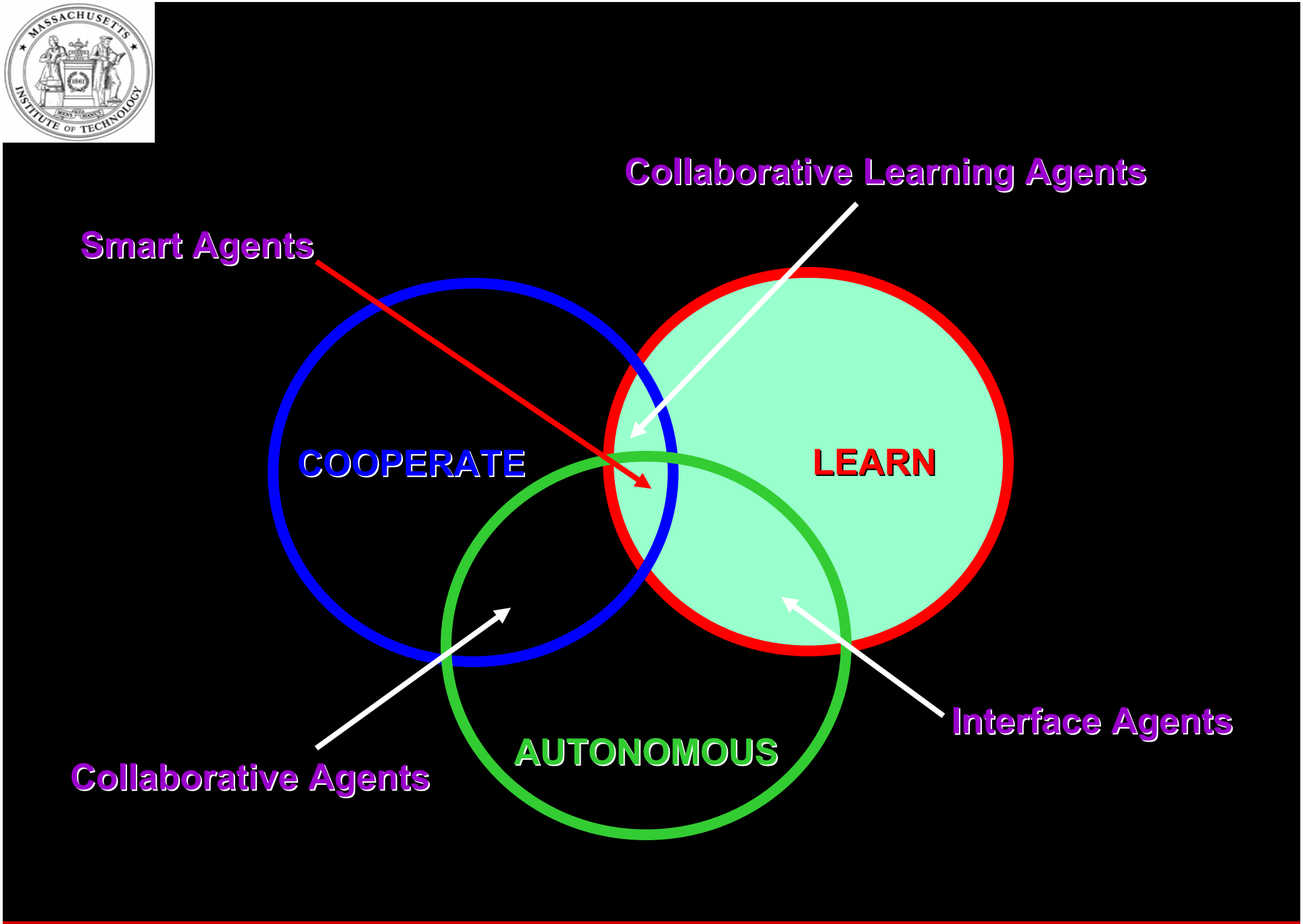
Swarm Intelligence: Ant–based Algorithms



- Pheromone

Adaptive ?




Collaborative Learning Agents
Smart Agents
COOPERATE
LEARN
AUTONOMOUS
Collaborative Agents
Interface Agents

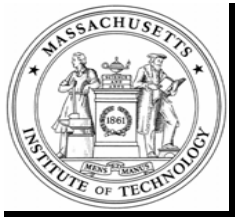
Executive Summary

- Concept — Relative Identification
- Application — Logistics, SCM, Healthcare, Security, eGov
- Tools — IPv6 Format and Semantics
- Benefits — Global Standard, Systems Interoperability

Executive Summary

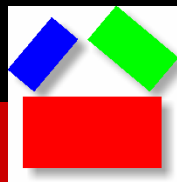
- Concept
- Application
- Tools
- Benefits

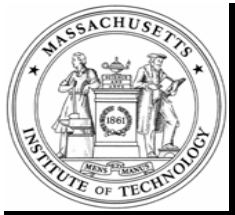
Semantics



Structure, Relations

```
<CompanyData>
   <CompanyName>
    MIT
   </CompanyName>
   <Location>
    Cambridge
   </location>
   <CallData>
     <RecordDate>
      Thu 7 Jun 2007
     </RecordDate>
     <CallsPerDay>
          536
     </CallsPerDay>
   </CallData>
</CompanyData>
```





Structure, Relations, Syntax

"CallsPerDay"

```
<CompanyData>
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    MIT
   </CompanyName>
   <Location>
    Cambridge
   </location>
   <CallData>
     <RecordDate>
      Thu 7 Jun 2007
     </RecordDate>
     <CallsPerDay>
          536
     </CallsPerDay>
   </CallData>
</CompanyData>
```

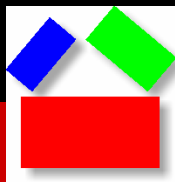

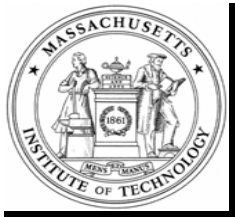

Structure, Relations, Syntax, Semantics

```
<CompanyData>
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   </CompanyName>
   <Location>
    Cambridge
   </location>
   <CallData>
     <RecordDate>
      Thu 7 Jun 2007
     </RecordDate>
     <CallsPerDay>
          536
     </CallsPerDay>
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```

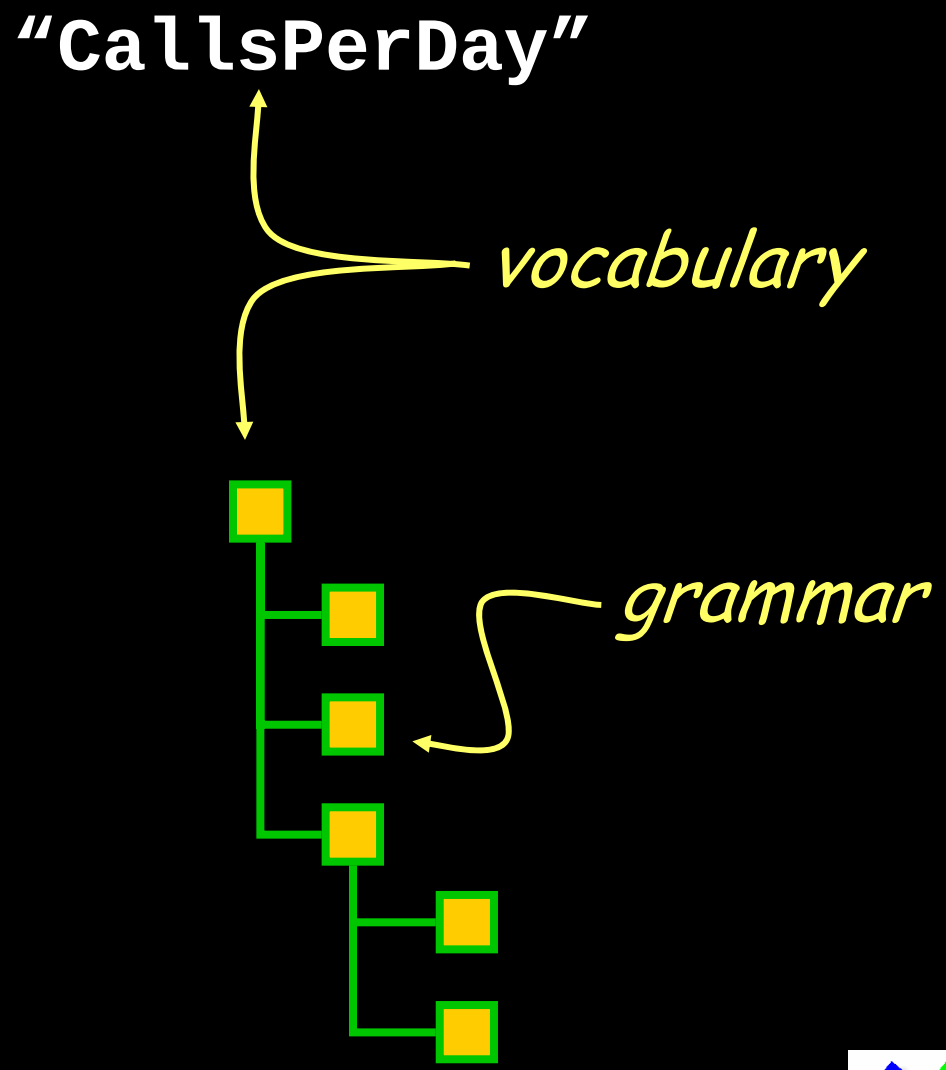

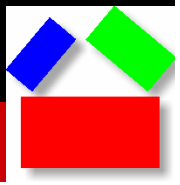

Data, Structure, Relations, Syntax, Semantics

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   </CompanyName>
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    Cambridge
   </location>
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     </CallsPerDay>
   </CallData>
</CompanyData>
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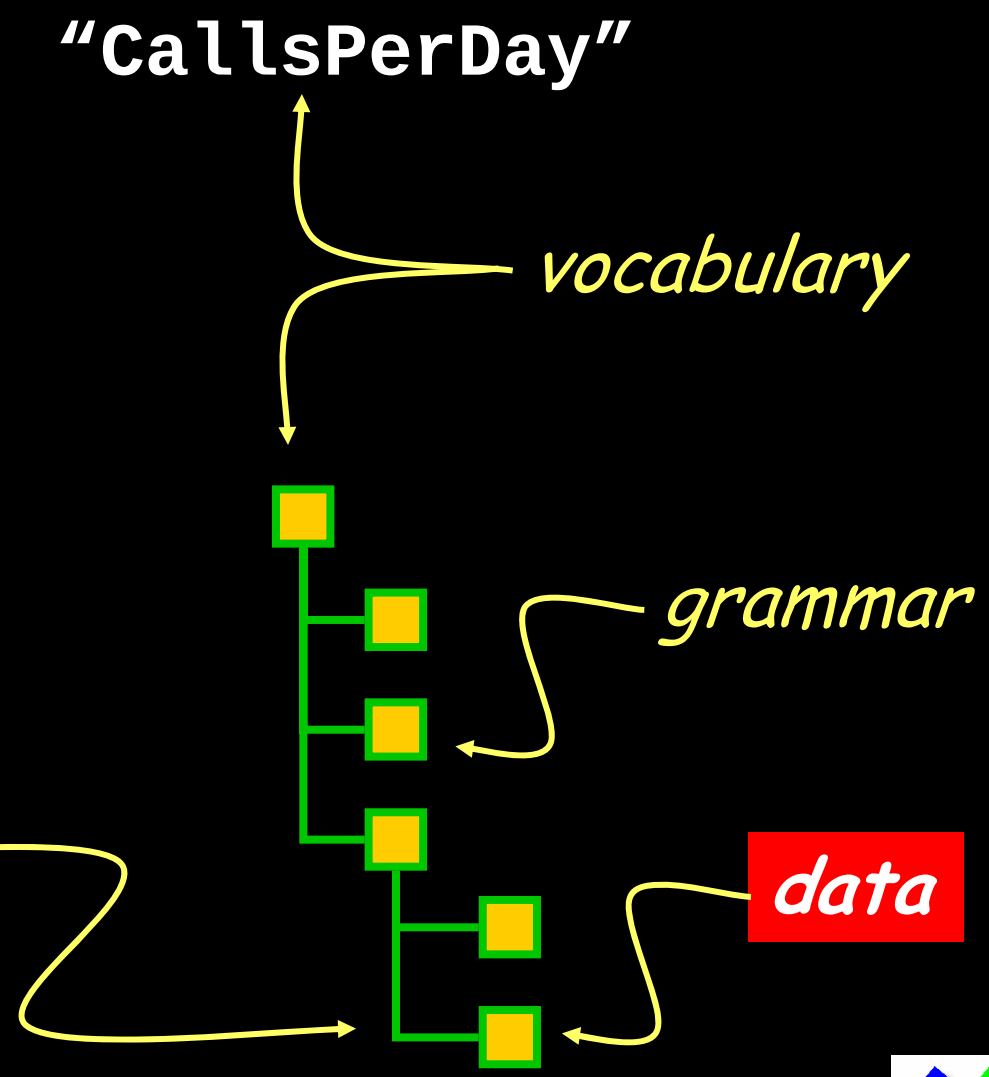
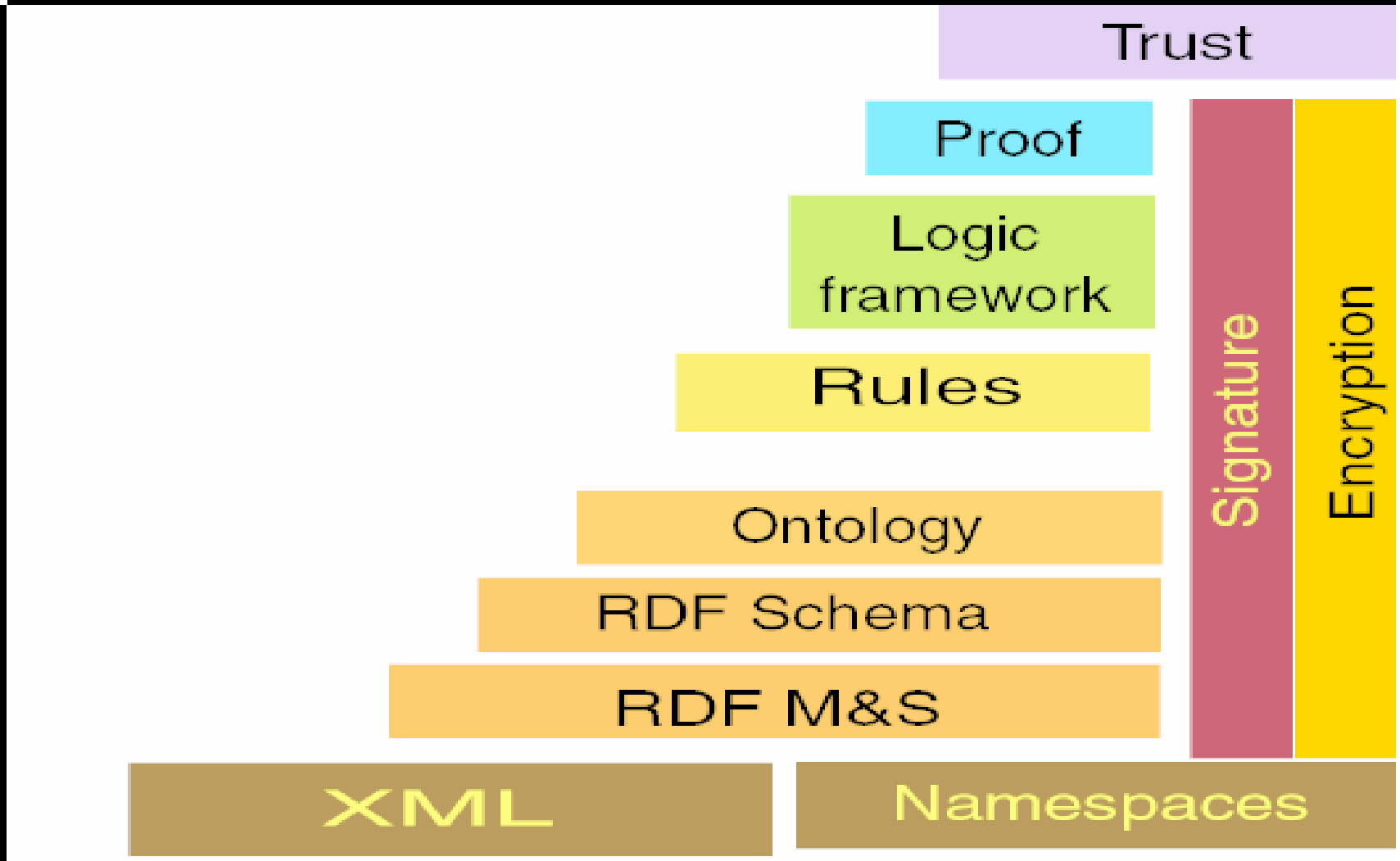


Dr Shoumen Palit Austin Datta < shoumen@mit.edu > MIT Forum for Supply Chain Innovation & MIT School of Engineering

Semantic Layers
Tim Berners-Lee, MIT



Semantic Layers
Tim Berners-Lee, MIT

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   <Location>
    Cambridge
   </location>
   <CallData>
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     </RecordDate>
     <CallsPerDay>
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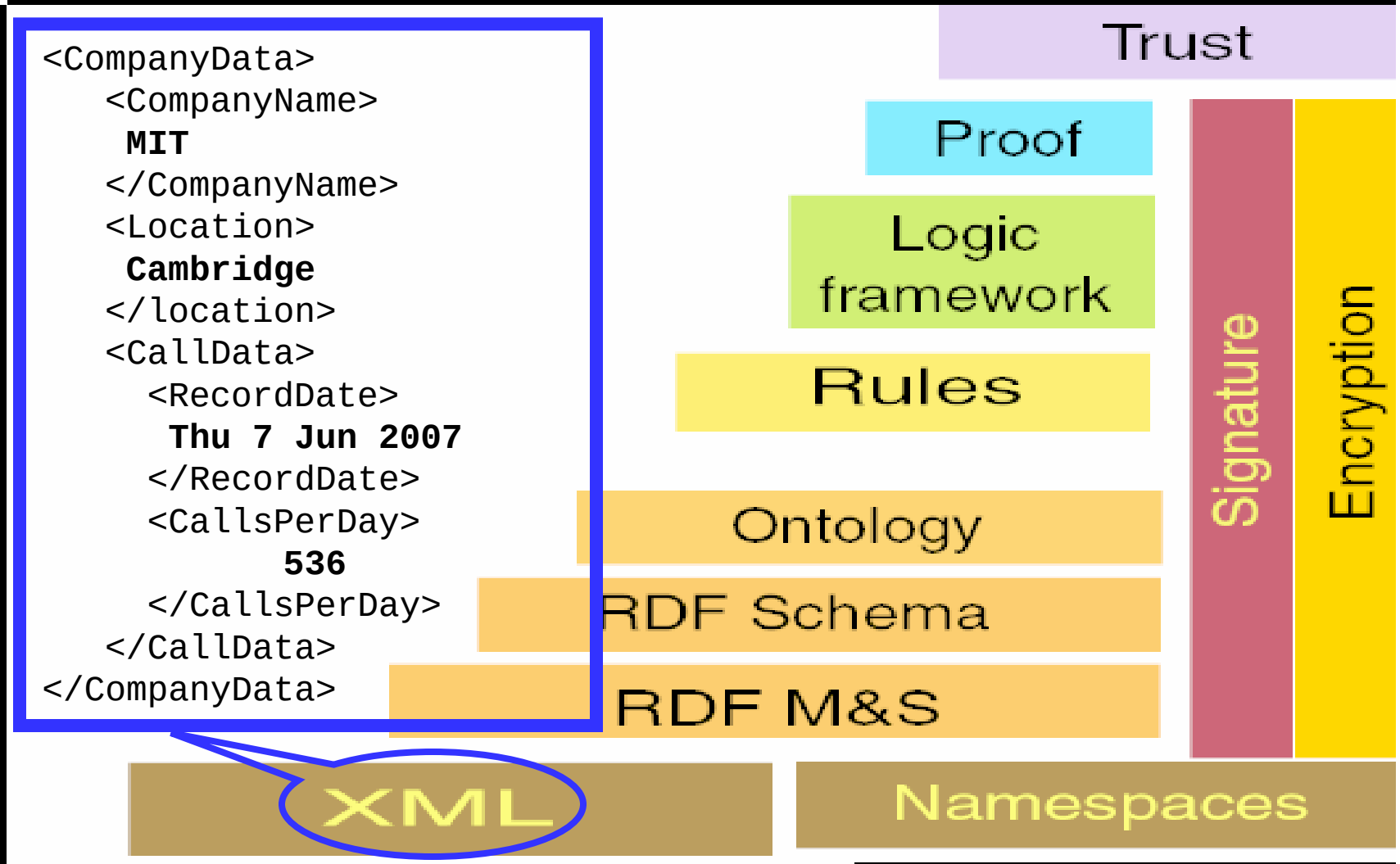
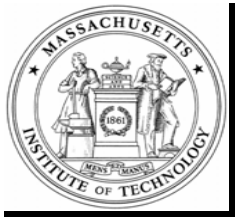
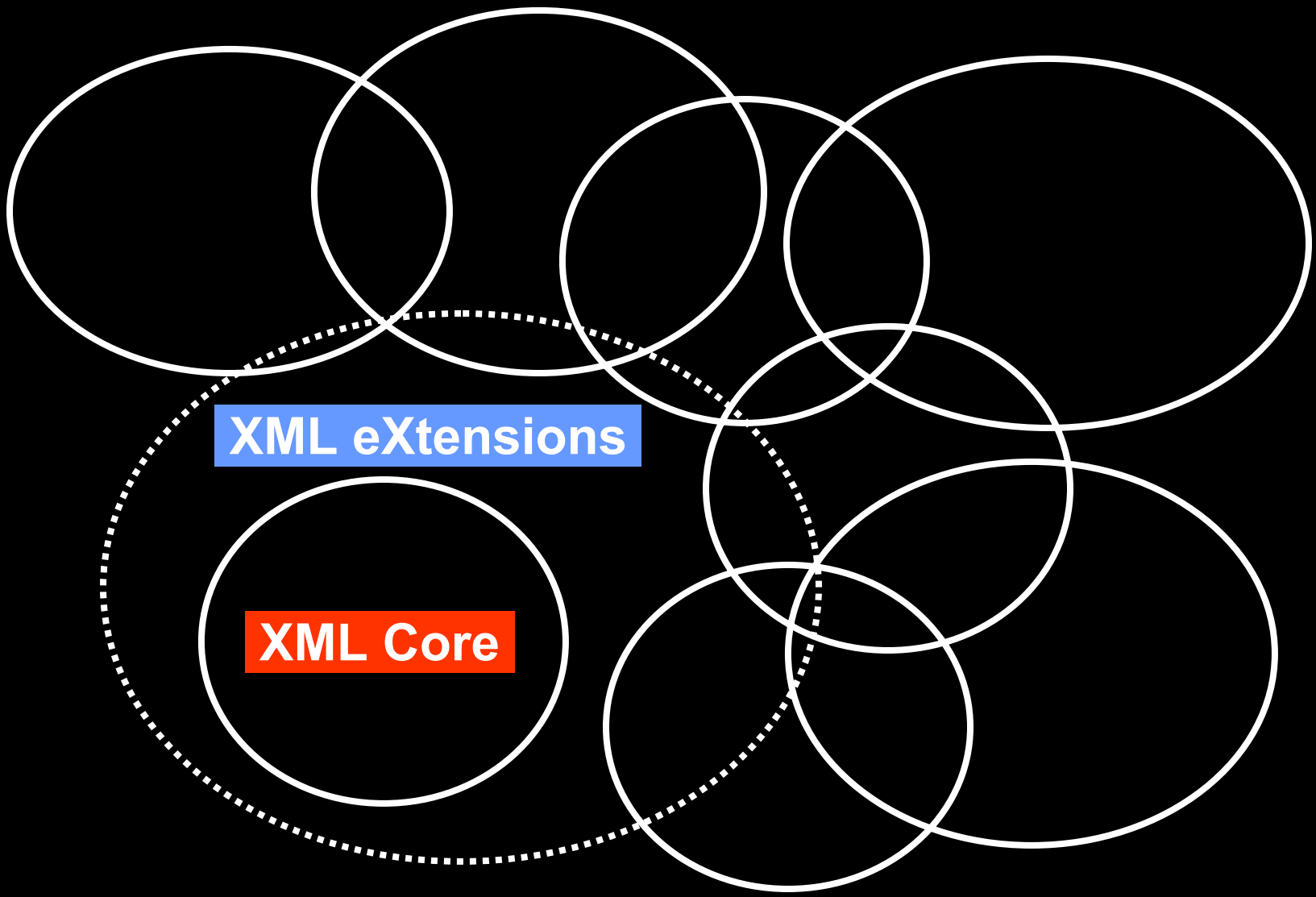
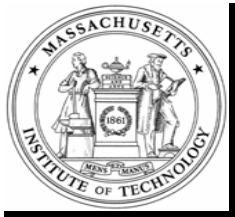




XML: Languages & Open Standards





Evolution

2003 Ontology Working Language (OWL) DAML + OIL
DARPA Agent Markup Language + Ontology Inference Layer

1999 XML-based Physical Markup Language (PML)
RFID Object Description Language (AIDC, MIT)

1998 eXtensible Markup Language (XML)
World Wide Web Consortium (W3C)

1996 eXtensible Markup Language (XML)
World Wide Web Consortium (W3C) Initiative

1993 HTML Browser Mosaic - Marc Andreessen
National Center for Supercomputing Applications (NCSA) University of Illinois

1989 HyperText Markup Language (HTML) - Tim Berners-Lee, CERN

1986 SGML - International Organization for Standardization (ISO)

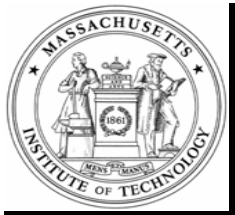
1983 SGML Computer Graphics Association (CGA)

1978 Standard General Markup Language (SGML) ANSI Initiative

1975 Document Composition Facility (DCF)

1971 Document Type Definition (DTD)

1969 General Markup Language (GML) - Charles Goldfarb, Ed Mosher, Ray Lorie



XML Explosion .....

Compiled by: David Brock

4ML
AML
AML
AML
AML
AML
ABML
ABML
ACML
ACML
ACAP
ACS X12
ADML
AECM
AFML
AGML
AHML
AIML
AIML
AIF
AL3
ANML
ANNOTEA
ANATML
APML
APPML
AQL
APPEL
ARML
ARML
ASML
ASML
ASTM
ARML
ARML
ASML

ARML
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AXML
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BML
BML
BML
BML
BML
BannerML
BCXML
BEEP
BGML
BHTML
BIBLIOML
BIOML
BIPS
BizCodes
BLM XML
BPML
BRML
BSML
BCXML
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BGML
BHTML

BiblioML
BCXML
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BIOML
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BizCodes
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BPML
BRML
BSML
CML
xCML
CaXML
CaseXML
xCBL
CBML
CDA
CDF
CDISC
CELLML
ChessGML
ChordML
ChordQL
CIM
CIML
CIDS
CIDX
xCIL
CLT
CNRP
ComicsML
CIM
CIML
CIDS

CIDX
xCIL
CLT
CNRP
ComicsML
Covad xLink
CPL
CP eXchange
CSS
CVML
CWMI
CycML
DML
DAML
DaliML
DaqXML
DAS
DASL
DCMI
DOI
DeltaV
DIG35
DLML
DMML
DocBook
DocScope
DoD XML
DPRL
DRI
DSML
DSD
DXS
EML
EML
DLML
EAD
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eBIS-XML
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GAME
GBXML
GDML
GEML
GEDML
GEN
GeoLang
GIML
GXD
GXL
Hy XM
HITIS
HR-XML
HRMML
HTML
HTTPL

HTTP-DRP
HumanML
HyTime
IML
ICML
IDE
IDML
IDWG
IEEE DTD
IFX
IMPP
IMS Global
InTML
IOTP
IRML
IXML
IXRetail
JabberXML
JDF
JDox
JECMM
JLife
JSML
JSML
JScoreML
KBML
LACITO
LandXML
LEDES
LegalXML
Life Data
LitML
LMML
LogML
LogML
LTSC XML
MAML

MatML
MathML
MBAM
MISML
MCF
MDDL
MDSI-XML
Metarule
MFDX
MIX
MMLL
MML
MML
MML
MoDL
MOS
MPML
MPXML
MRML
MSAML
MTML
MTML
MusicXML
NAML
xNAL
NAA Ads
Navy DTD
NewsML
NML
NISO DTB
NITF
NLMXML
NVML
OAGIS
OBI
OCF
ODF

ODRL
OeBPS
OFX
OIL
OIM
OLifE
OML
ONIX DTD
OOPML
OPML
OpenMath
Office XML
OPML
OPX
OSD
OTA
PML
PML
PML
PML
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RDL
RecipeML
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RELAX NG
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RoadmOPS
RosettaNet PIP
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TREX
TxLife

UML
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UCLP
UDDI
UDEF
UIML
ULF
UMLS
UPnP
URI/URL
UXF
VML
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vCard
VCML
VHG
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VMML
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WITSML
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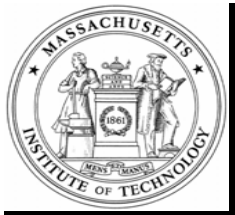

Houston, we have a problem ...

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IMPP
IMS Global
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LandXML
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Navy DTD
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NISO DTB
NITF
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NVML
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OeBPS
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OML
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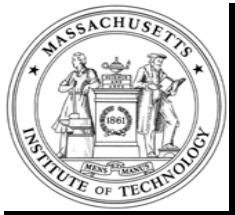
XNS

Compiled by: David Brock, MIT Data Center



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XMSG
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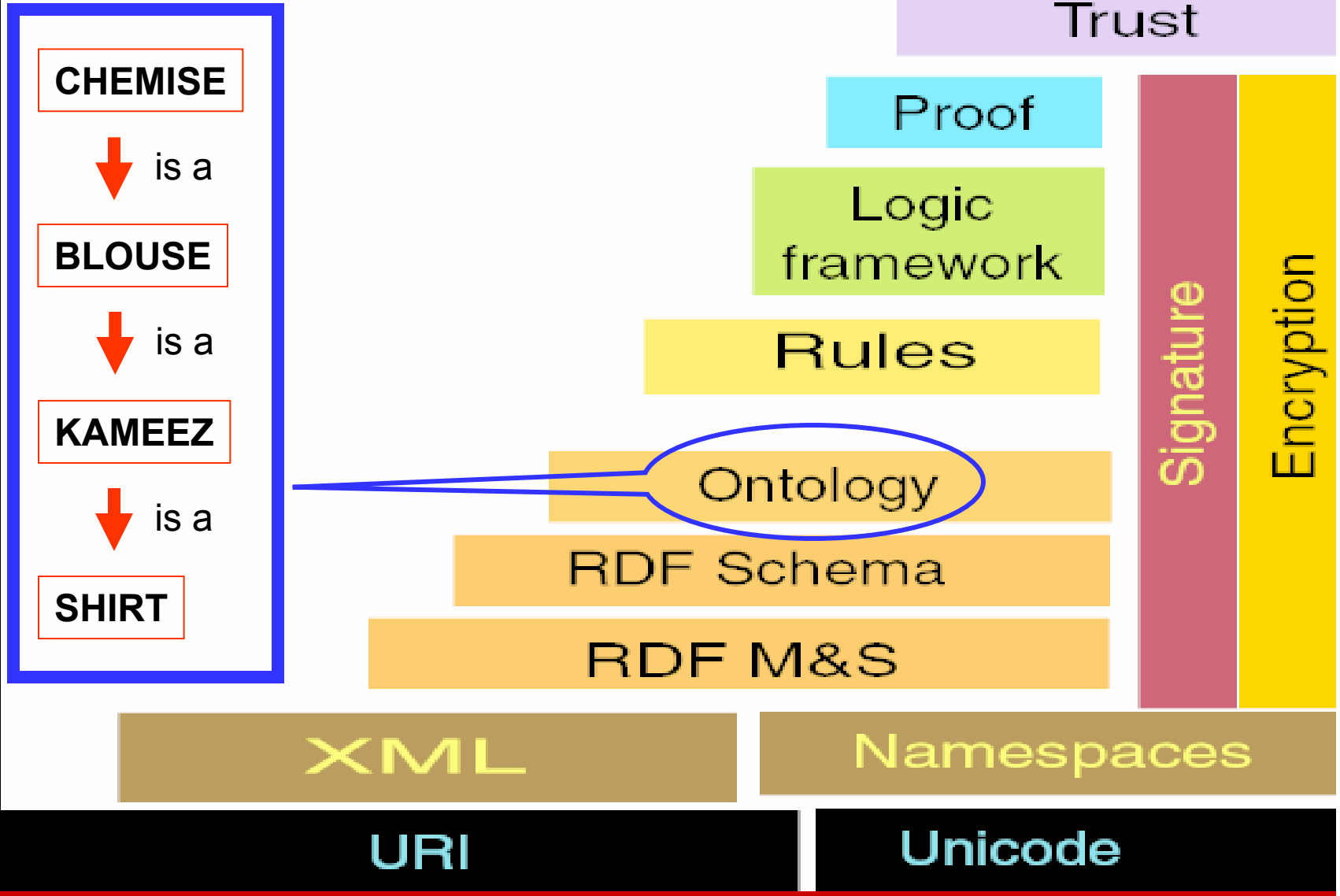
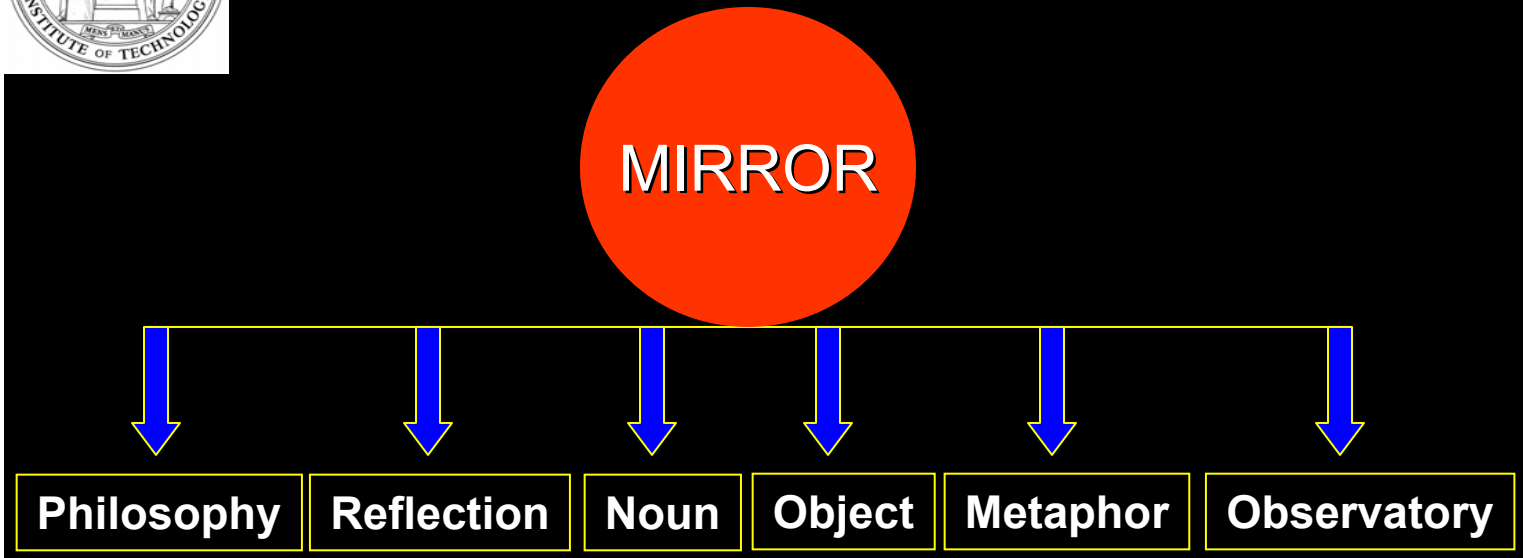
XNS

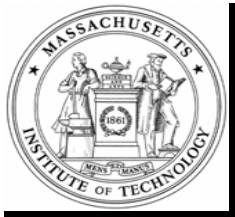
Is XML still a standard ?

Semantic Layers: Relationships
Tim Berners-Lee, MIT



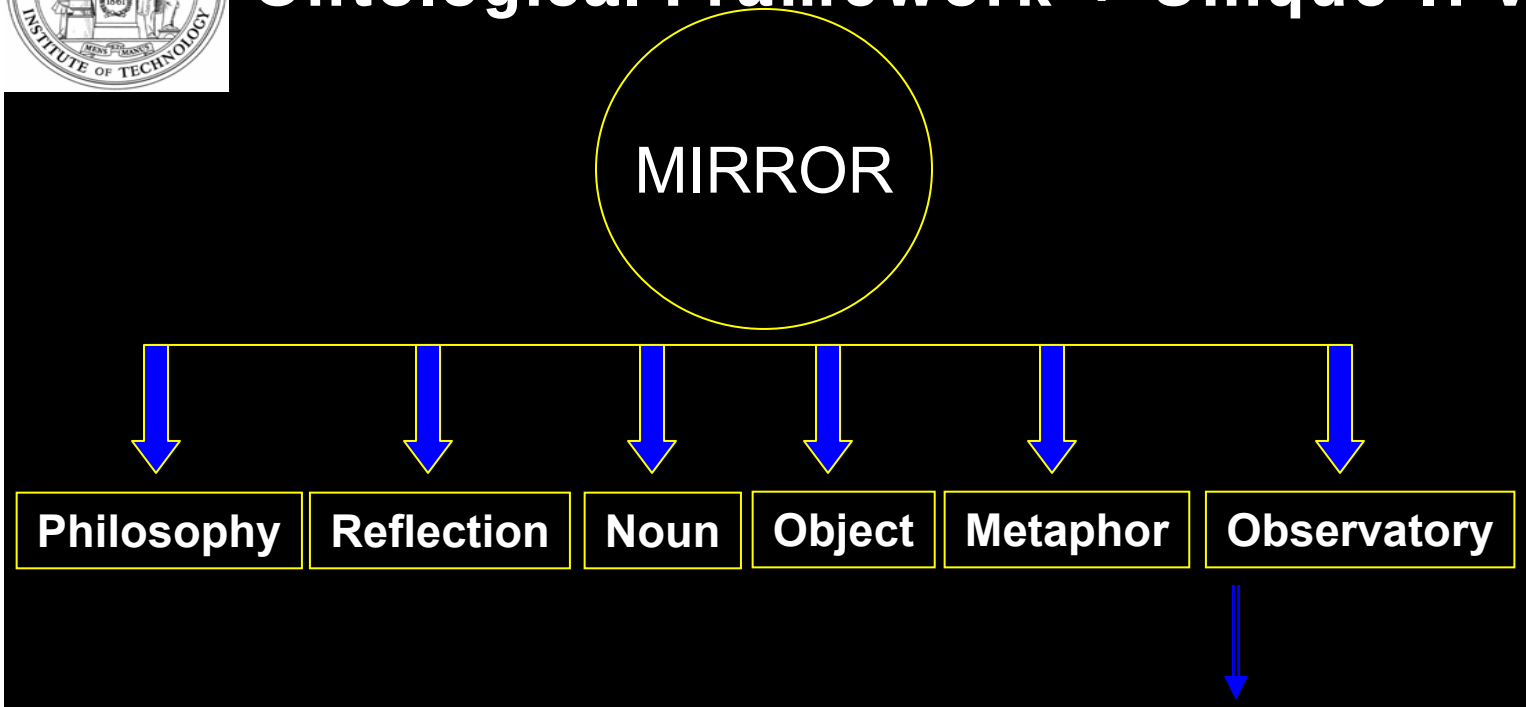
Ontological Framework





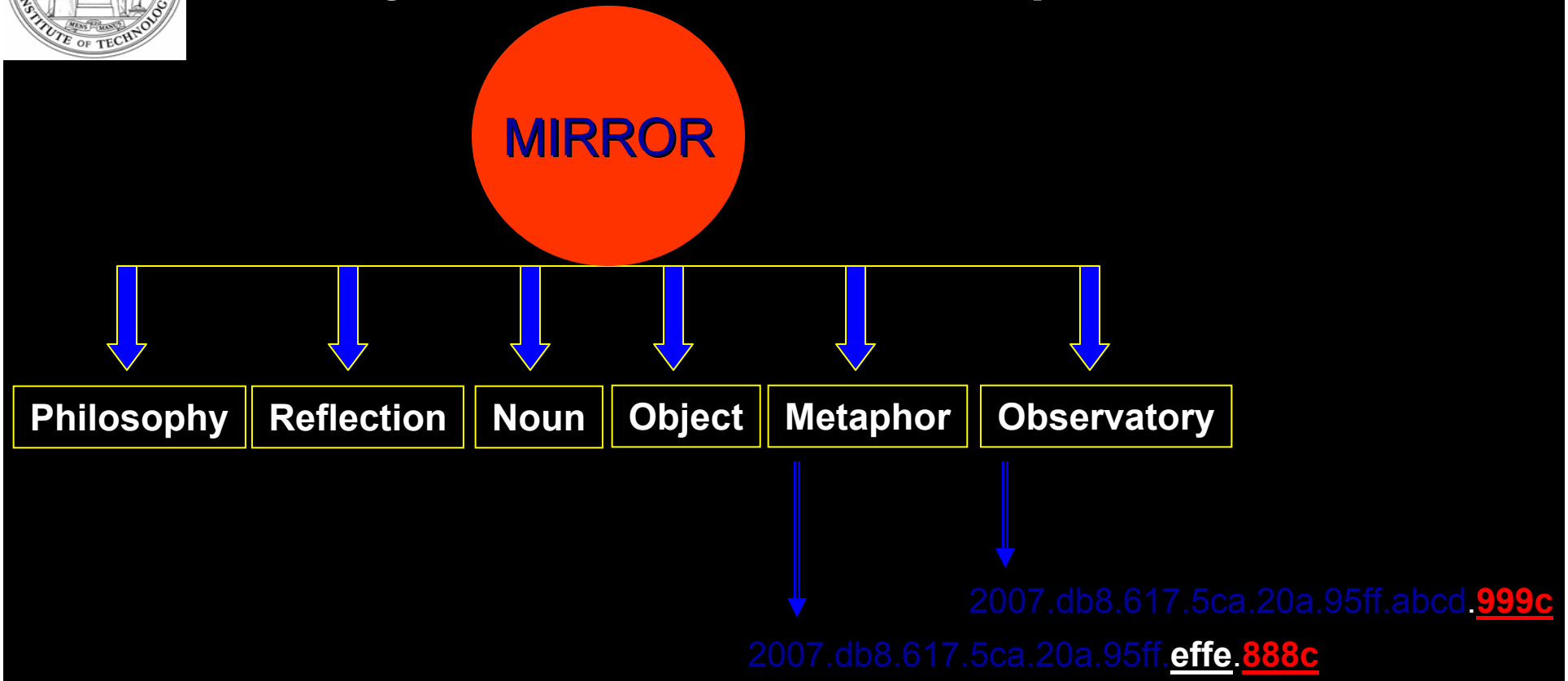
This is a proposed idea by the author. It is not a fact or form of identification of ontologies, in practice.

Ontological Framework + Unique IPv6 Identifier



2007.db8.617.5ca.20a.95ff.abcd.**999c**

Ontological Framework + Unique IPv6 Identifier



Dr Shoumen Palit Austin Datta < shoumen@mit.edu > MIT Forum for Supply Chain Innovation & MIT School (

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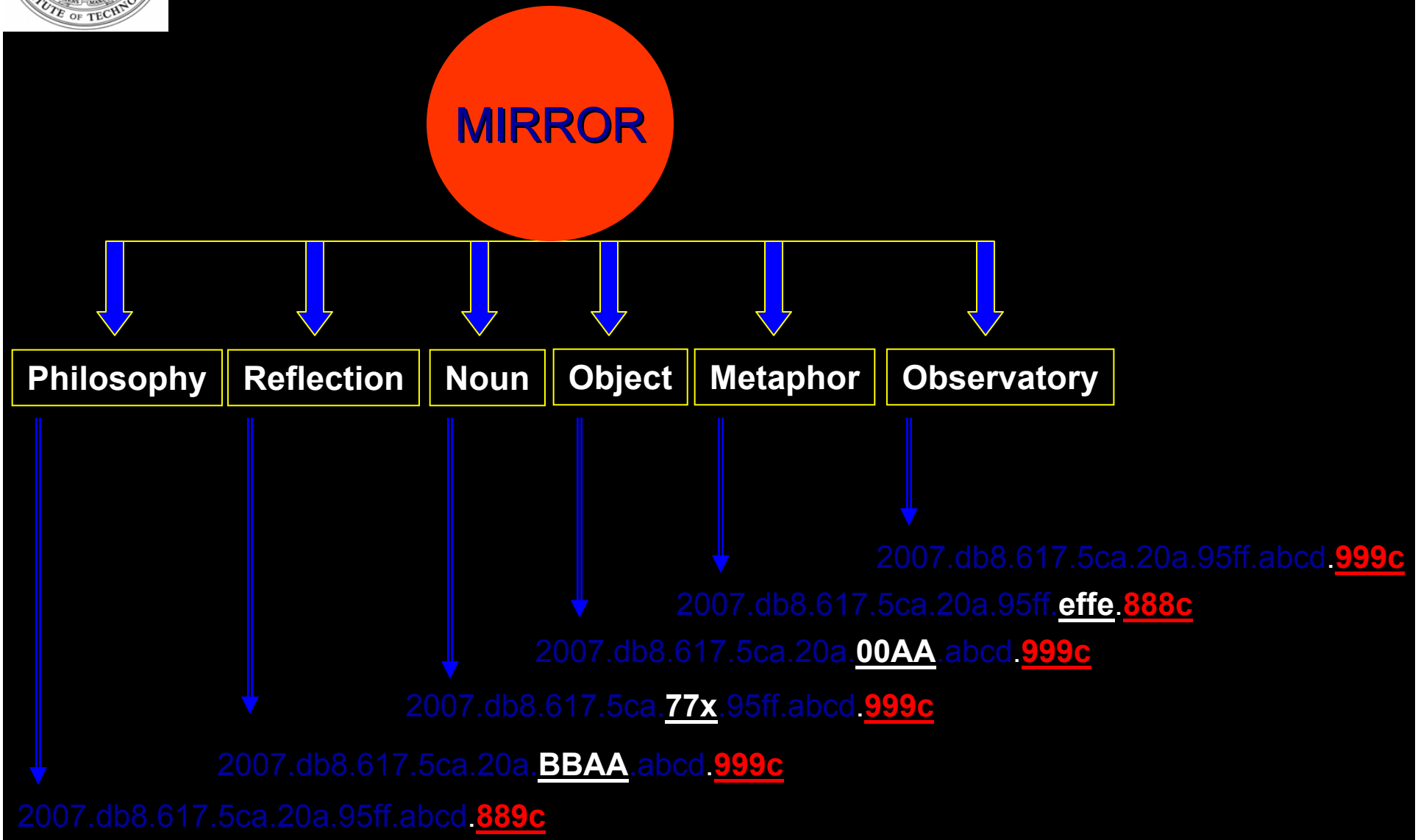
Unique IPv6 id: Ontological Identifier



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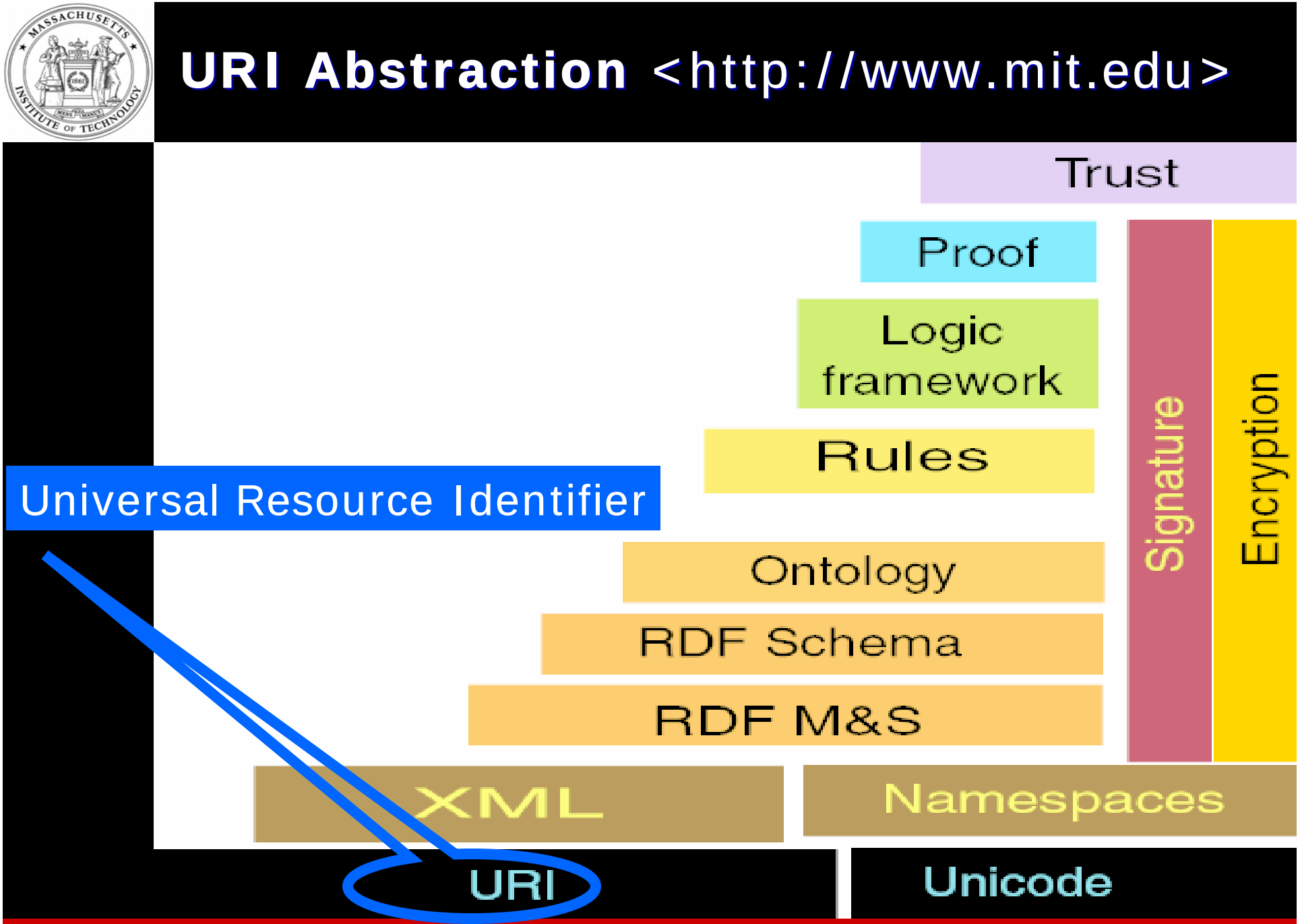
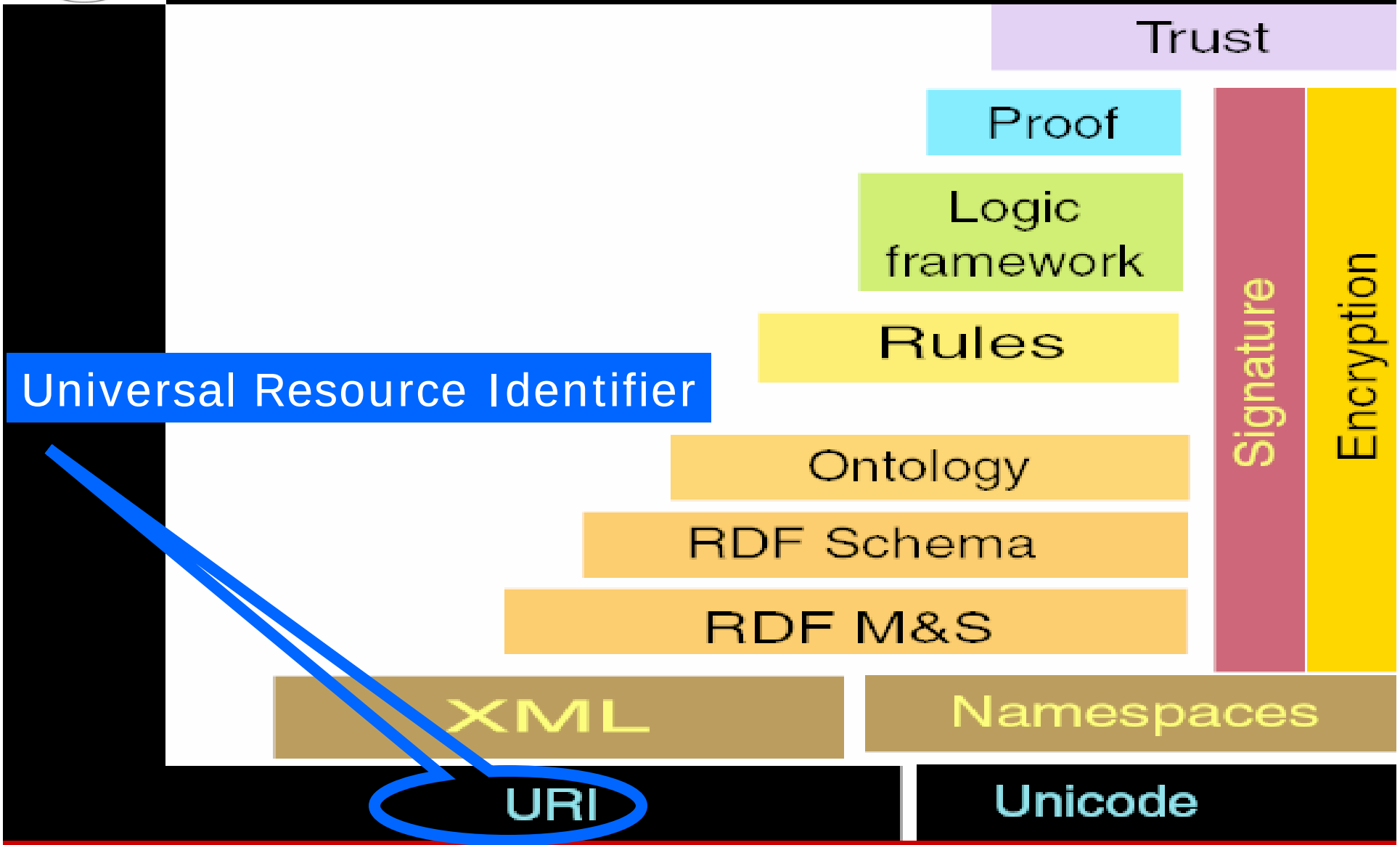
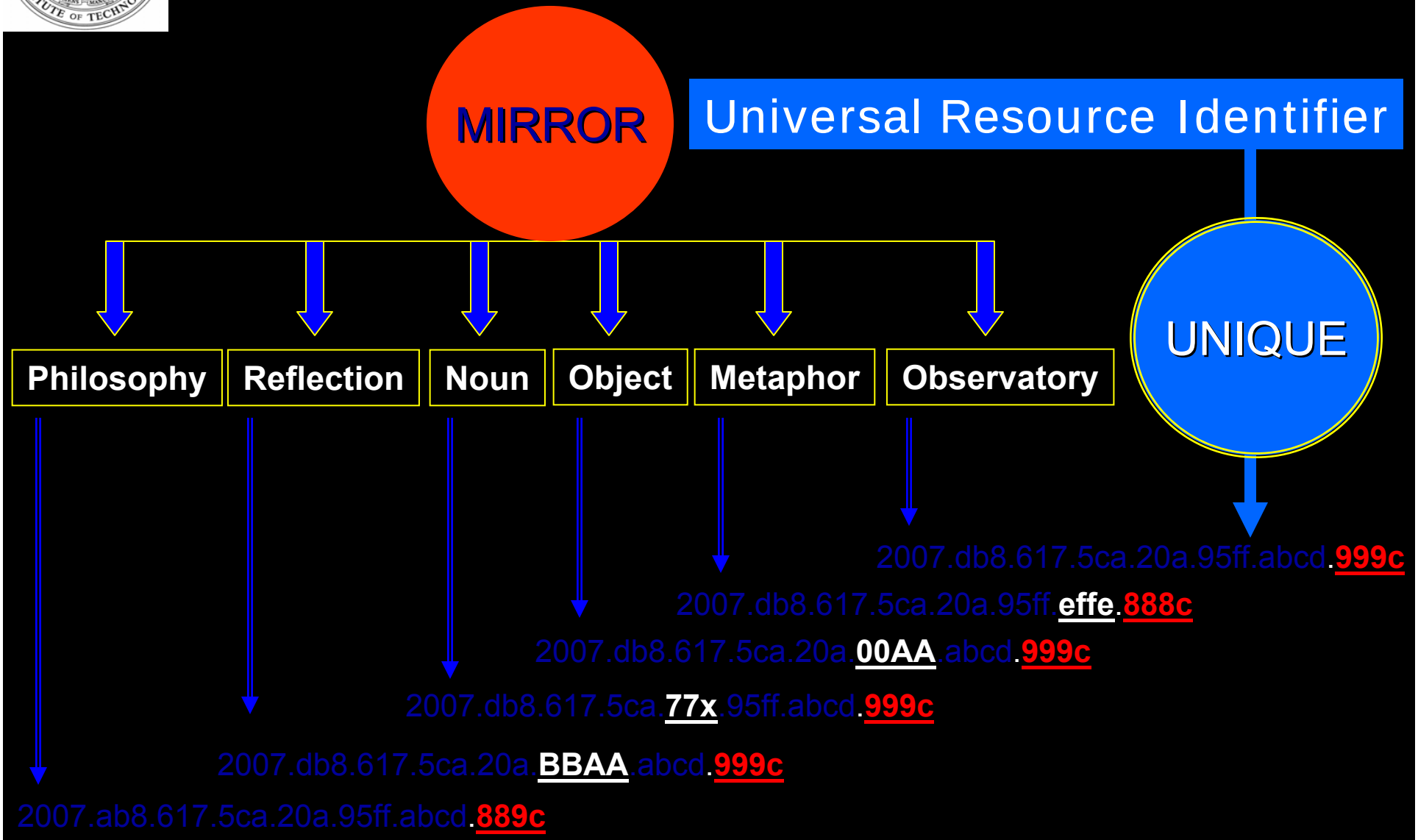

URI Abstraction <http://www.mit.edu>
Trust
Proof
Logic framework
Rules
Universal Resource Identifier
Ontology
RDF Schema
RDF M&S
Signature
Encryption
XML
Namespaces
URI
Unicode

URI: Universal but not Unique Identifier



Digital Ontology: Use IPv6 id over URI ?



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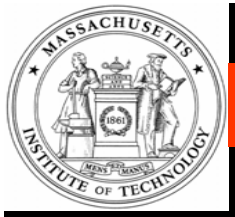

Unique IPv6 type id as a sub-layer to URI abstraction ?

MIRROR

Universal Resource Identifier

UNIQUE

Philosophy | Reflection | Noun | Object | Metaphor | Observatory

2007.ab8.617.5ca.20a.95ff.abcd.**889c**

2007.db8.617.5ca.20a.**BBAA**.abcd.**999c**

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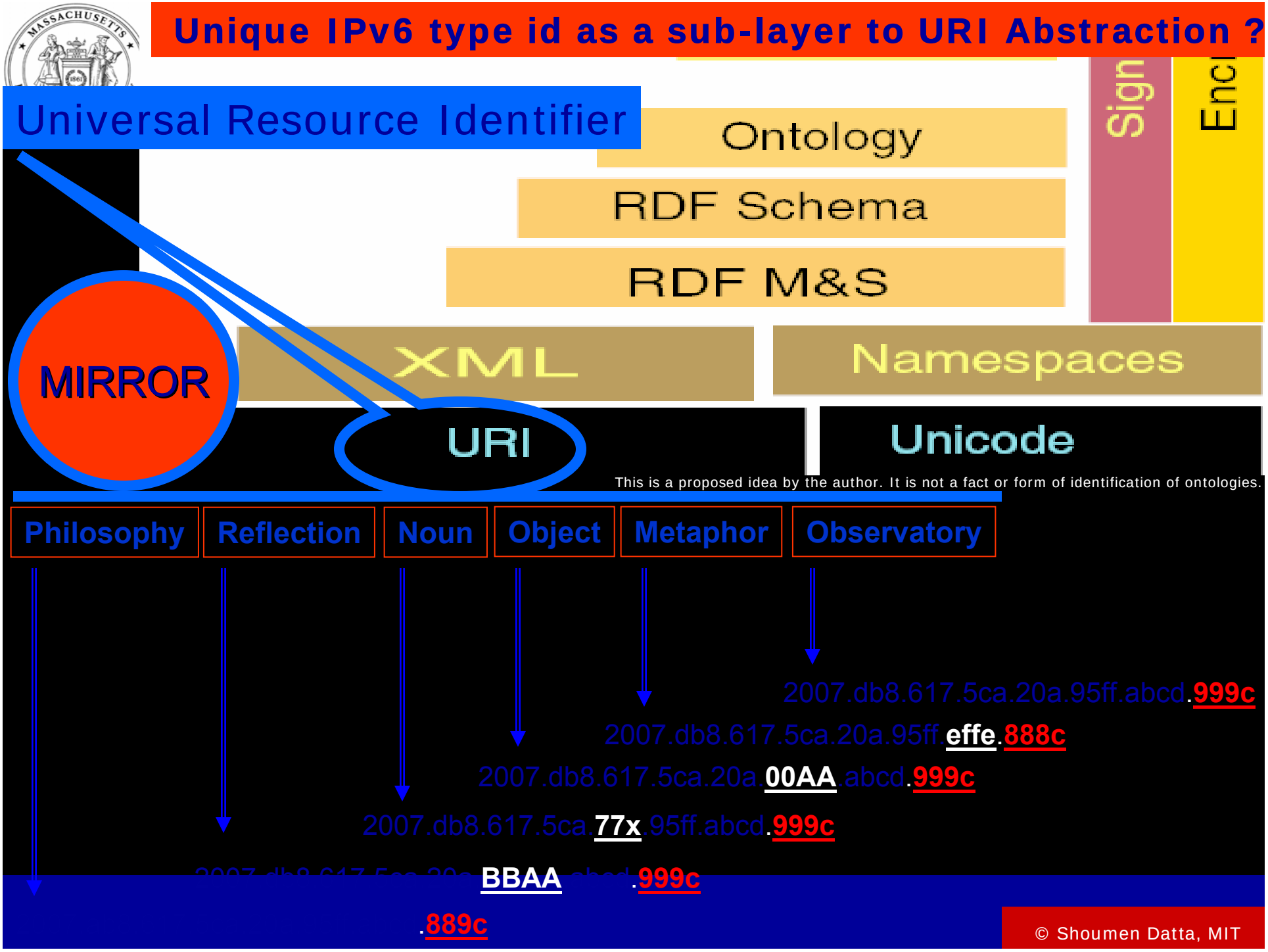

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Class

Upperbody Outerwear

IPv6 Range →

2007. db8. 617. 5ca. 20a. 95ff. **200a. 0000**
to
2007. db8. 617. 5ca. 20a. 95ff. **400f. 8888**

Unique IPv6 type id as a sub-layer to URI Abstraction ?

CHEMISE 2007.db8.617.5ca.20a.95ff.**320a.1617**

↓ is a

BLOUSE 2007.db8.617.5ca.20a.95ff.**320b.0452** →

Serial Number

Additional identification may be included in the encapsulating security header section for data integrity or 'uniqueness'

↓ is a

SHIRT 2007.db8.617.5ca.20a.95ff.**320c.3211** →

↓ **is it a ?**

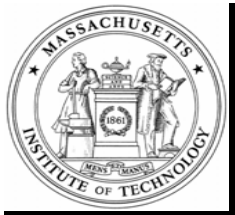
KAMEEZ
2007.db8.617.5ca.20a.95ff.**300d.2020**

↓ **is a ?**

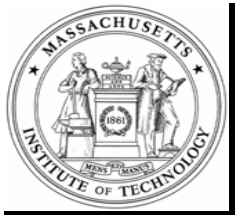
KIMONO
2007.db8.617.5ca.20a.95ff.**203f.8080**

Subclass:
Japanese Traditional Outer Garments
Range:
2007.db8.617.5ca.20a.95ff.**202a.7777**
to
2007.db8.617.5ca.20a.95ff.**210f.9999**

Shoumen Datta, MIT



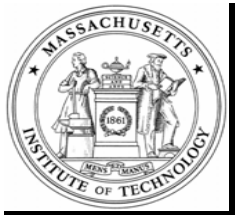
Why is it necessary to define ontology class with unique id ?



Why is it necessary to define ontology class with unique id ?

Global Agreement

- **Anterior Pituitary is a part of hypothalamus**
- **Minute Hand is a part of a time clock**



Why is it necessary to define ontology class with unique id ?

Language Ambiguity

Class

Upperbody Outerwear

Why is it necessary to define ontology class with unique id ?

CHEMISE

is a

BLOUSE

is a

SHIRT

is it a ?

KAMEEZ

is a ?

KIMONO

Western Ontology Classification

Kimono

is a

Shirt

Class

Upperbody Outerwear

CHEMISE

is a

BLOUSE

is a

SHIRT

is it a ?

KAMEEZ

is a ?

KIMONO

Why is it necessary to define ontology class with unique id ?

X

Japanese Ontology Classification

Kimono

is a

Traditional Garment

Unique id eliminates semantic ambiguity

Class

Upperbody Outerwear

CHEMISE

is a

BLOUSE

is a

SHIRT

is it a ?

KAMEEZ

is a ?

KIMONO

2007.db8.617.5ca.20a.95ff.203f.8080

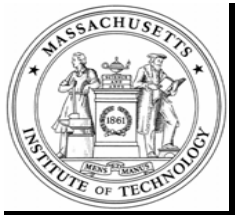
Unique id enables classification agnostic application

Western Ontological Framework

Japanese Ontological Framework

Subclass or a Separate Class:
Japanese Traditional Outer Garments
Range:
2007.db8.617.5ca.20a.95ff.202a.7777
to
2007.db8.617.5ca.20a.95ff.210f.9999

Shoumen Datta, MIT



Semantics

Call
Loud cry, shout

Call
Animal's call

Call
Telephone call

Call
House visit

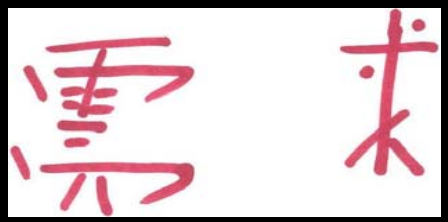
Semantics and Chinese Script

Call 1
Loud cry, shout

Call 2
Animal's call

Call 3
Telephone call

Call 4
House visit



Semantic Differences

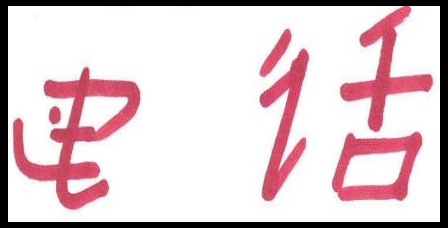
Call 1
Loud cry, shout

喊叫

Call 2
Animal's call

嚎叫

Call 3
Telephone call



电话

Call 4
House visit

需求

Semantic Ambiguity ?

Call 1
Loud cry, shout

喊叫

Call 2
Animal's call

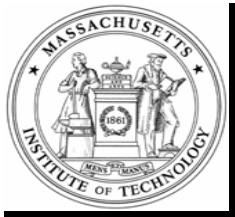
嚎叫

Call 3 →
Telephone call

电话

Call 4 →
House visit

需求



OMICS

CELL Ontology

```
[Term]
id: CL:0000236
name: B-cell
is_a: CL:0000542 ! lymphocyte
develops_from: CL:0000231 ! B-lymphoblast
```

Augmented GO

```
[Term]
id: GO:0030183
name: B-cell differentiation
is_a: GO:0042113 ! B-cell activation
is_a: GO:0030098 ! lymphocyte differentiation
intersection_of: is_a GO:0030154 ! cell differentiation
intersection_of: has_participant CL:0000236 ! B-cell
```

Data: Suzanna Lewis, GO Consortium and National Center for Biomedical Ontology

OMICS

Is it possible? Transition to IPv6 Format

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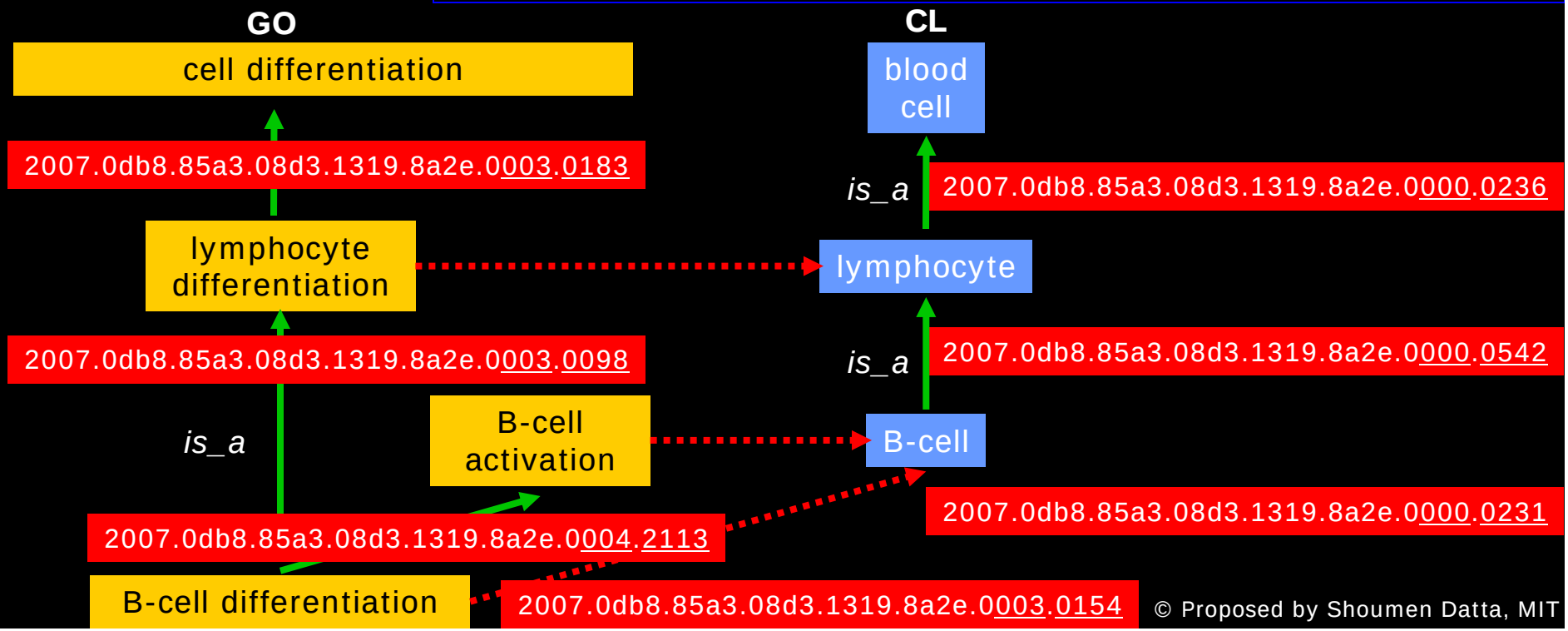
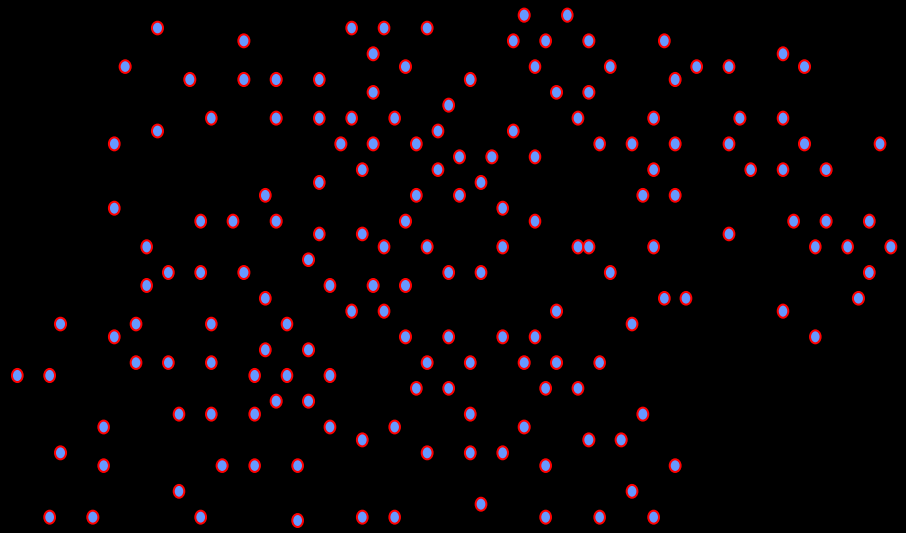
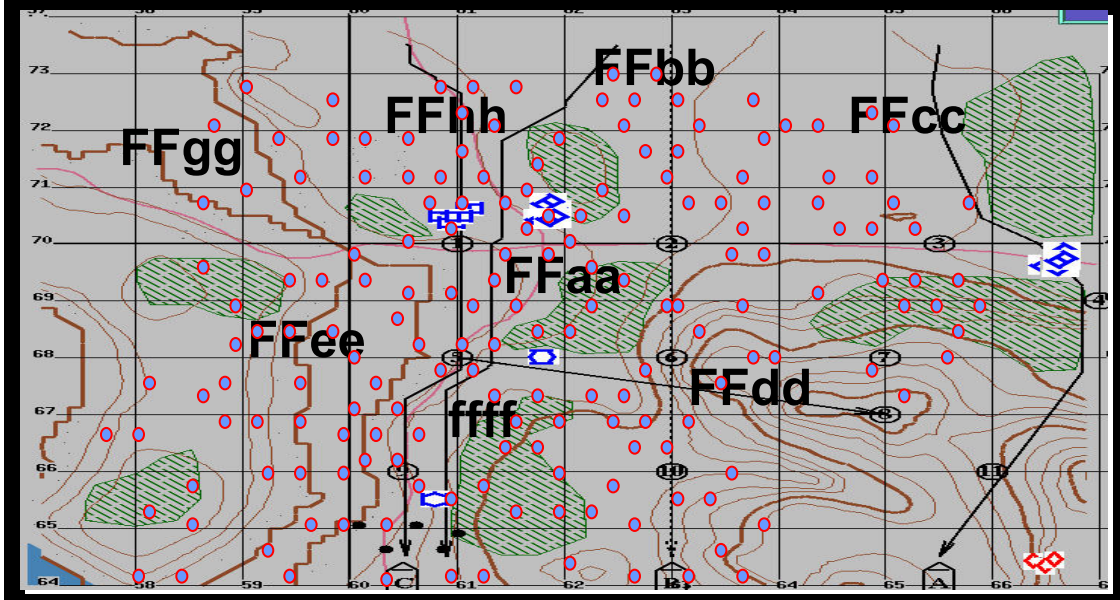


Defense: Mobile *ad hoc* Networks in Remote Sensing



Sensors
Light
Magnetic
Vibration

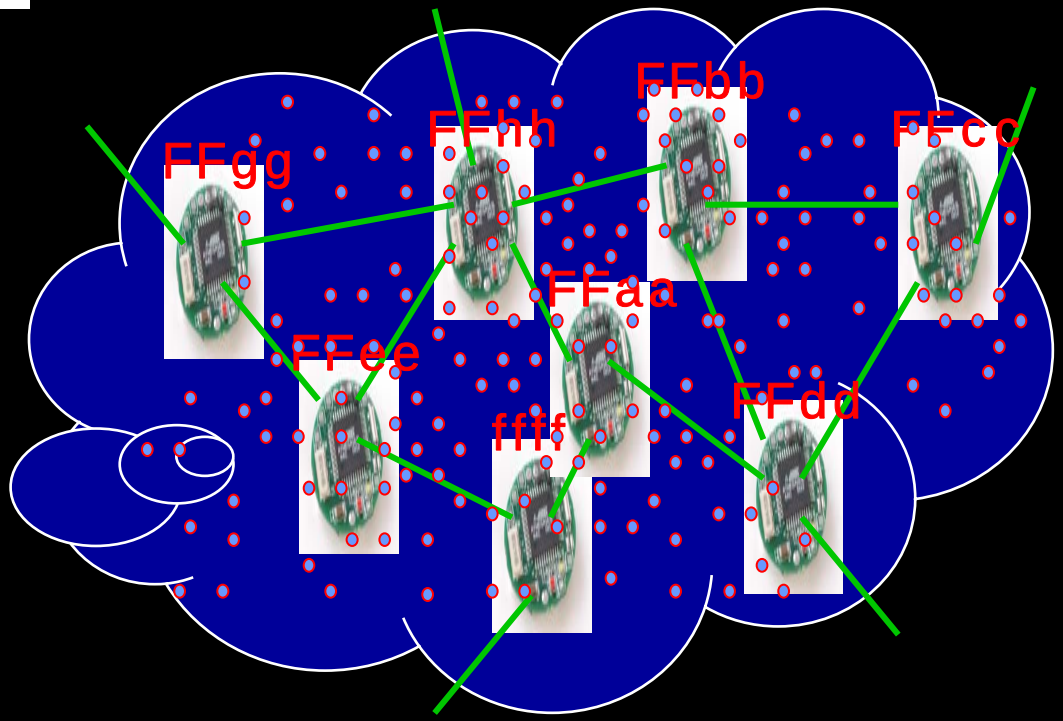
Defense: Mobile *ad hoc* Networks in Remote Sensing



FFxx **Unique Sensor Node**
Mobile Cluster Agent

Sensors
Light
Magnetic
Vibration

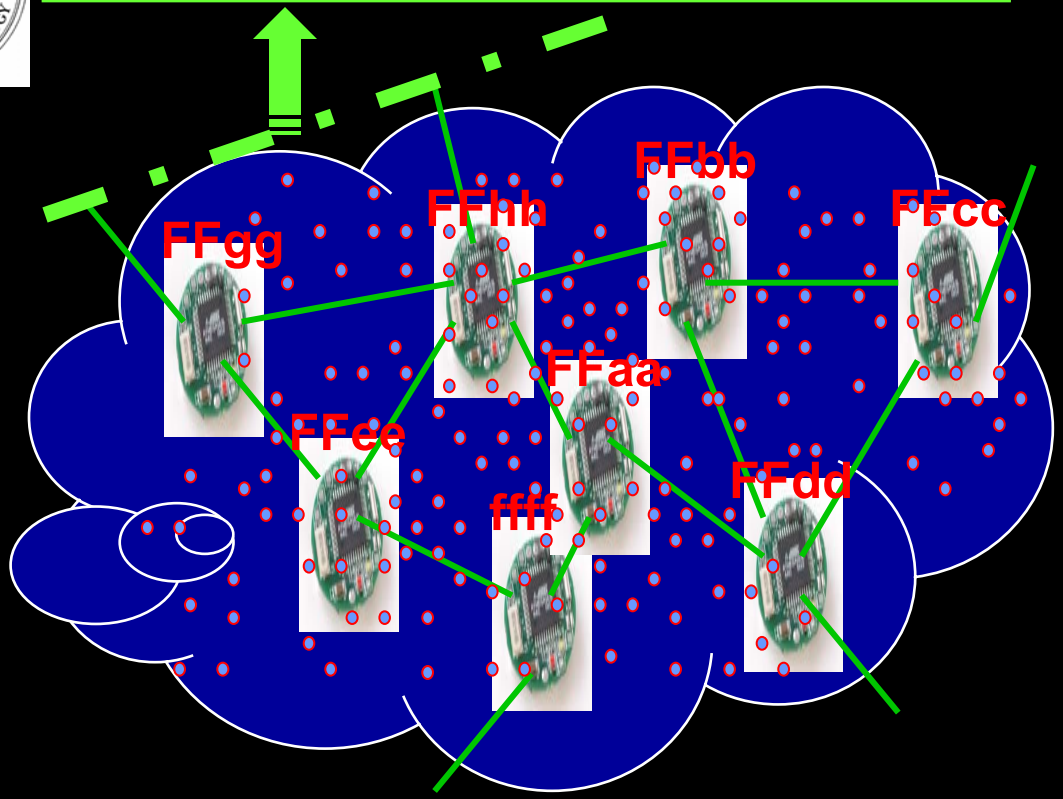
Defense: Mobile *ad hoc* Networks in Remote Sensing



FFxx **Unique Sensor Node**
Mobile Cluster Agent

Sensors
Light
Magnetic
Vibration

∑ (FFee, FFgg, FFhh) = background



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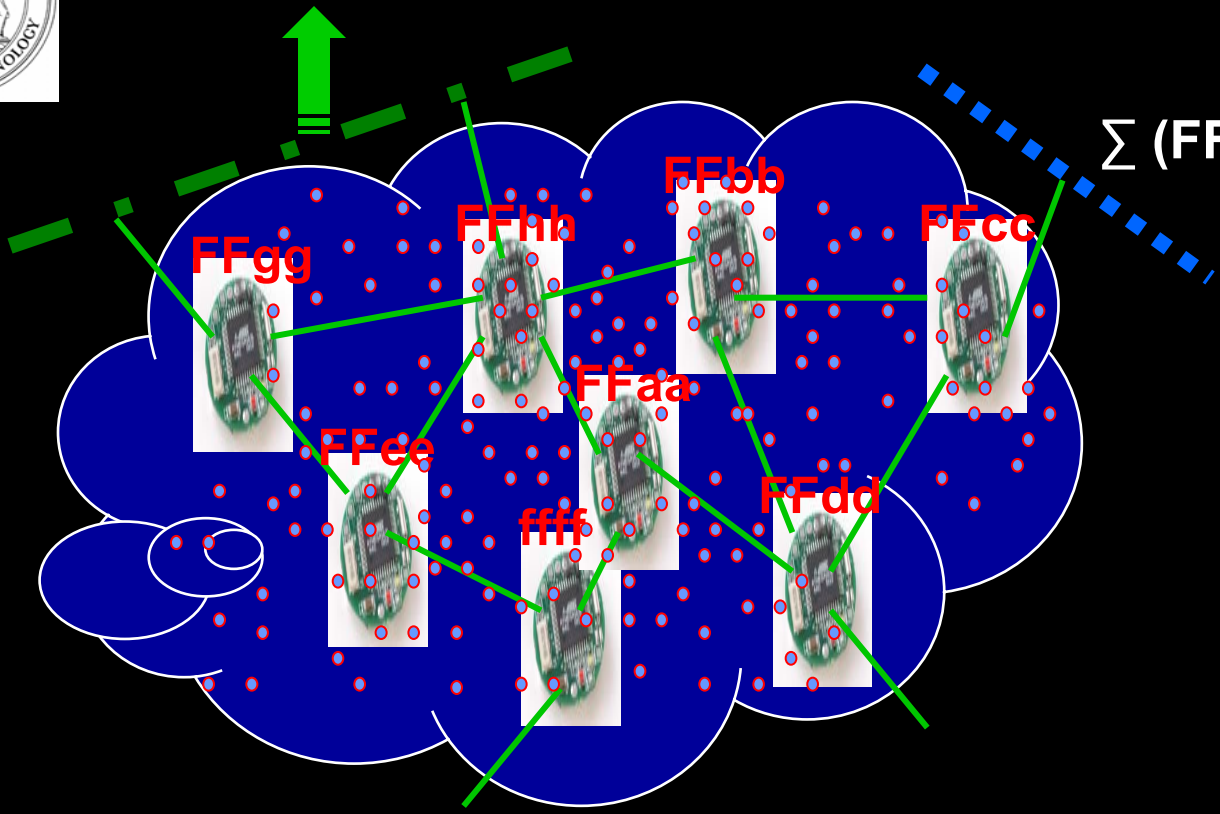
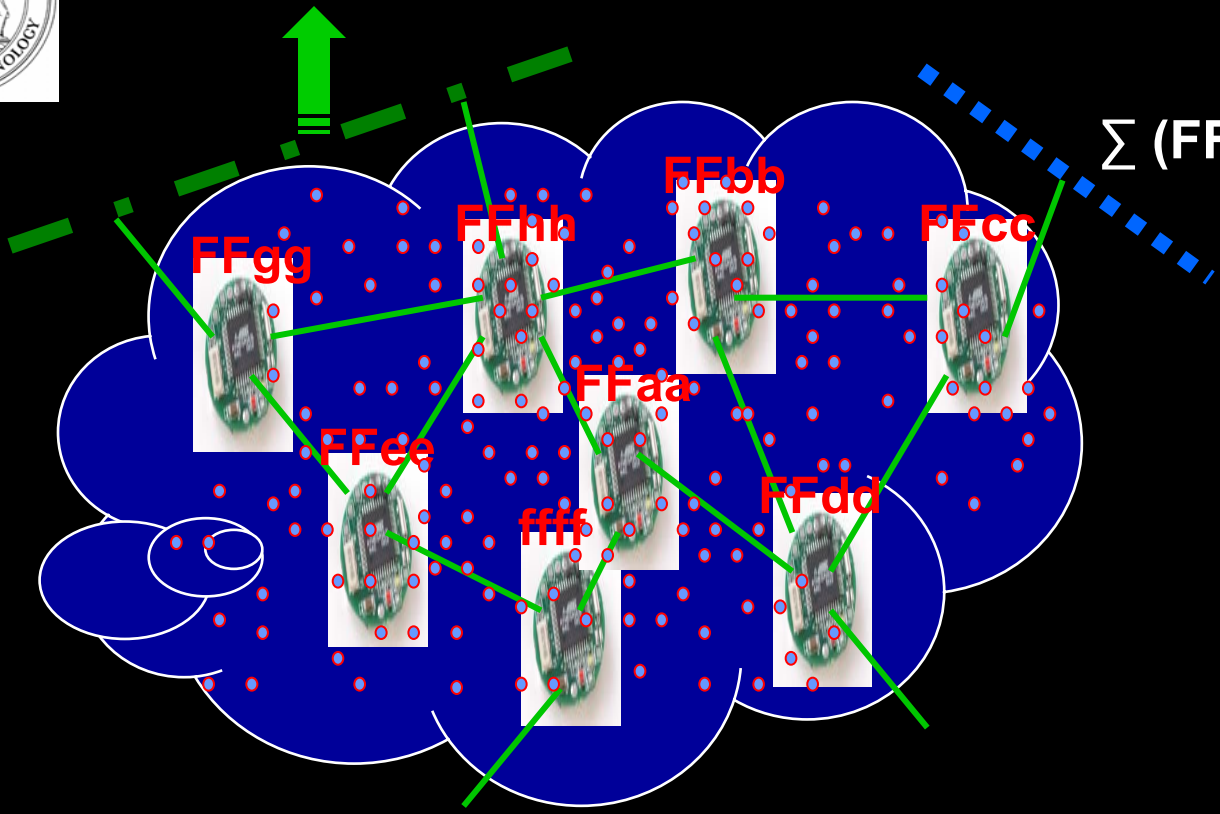


∑ (FFcc, FFbb) = low

FFxx **Unique Sensor Node**
Mobile Cluster Agent

Sensors
Light
Magnetic
Vibration

∑ (FFee, FFgg, FFhh) = background



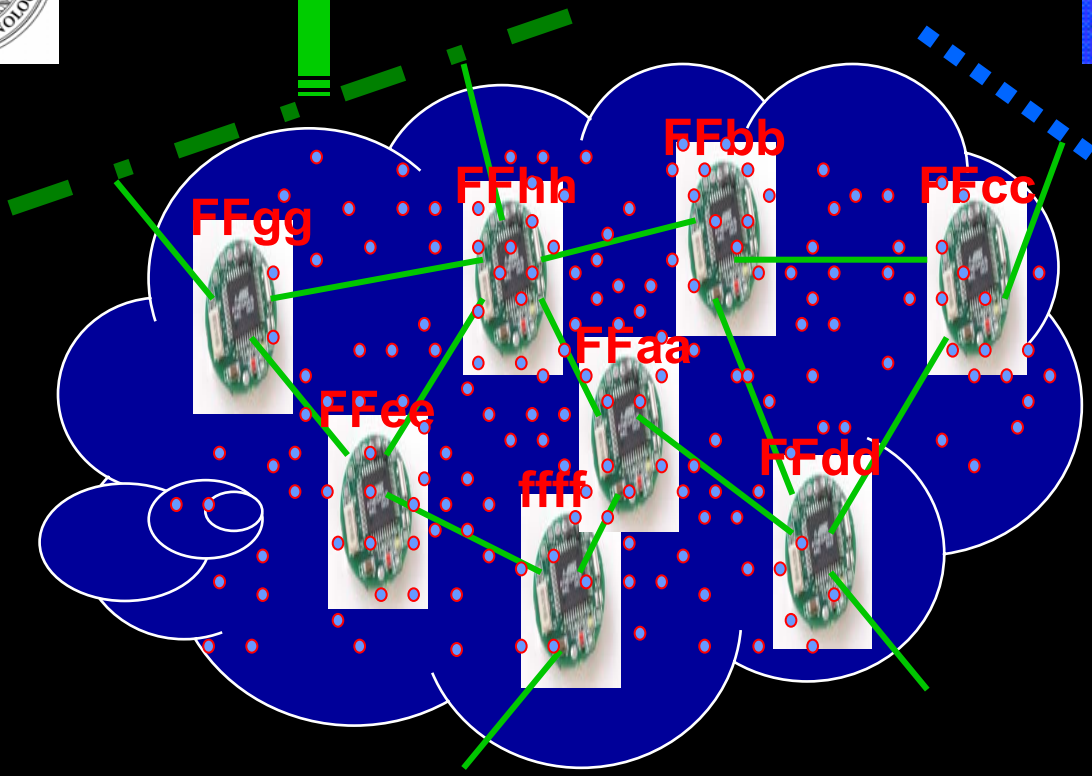
∑ (FFcc, FFbb) = low

Single Vehicle Approaching ?

FFxx **Unique Sensor Node**
Mobile Cluster Agent

Sensors
Light
Magnetic
Vibration

∑ (FFee, FFgg, FFhh) = background



Unique Analysis Id

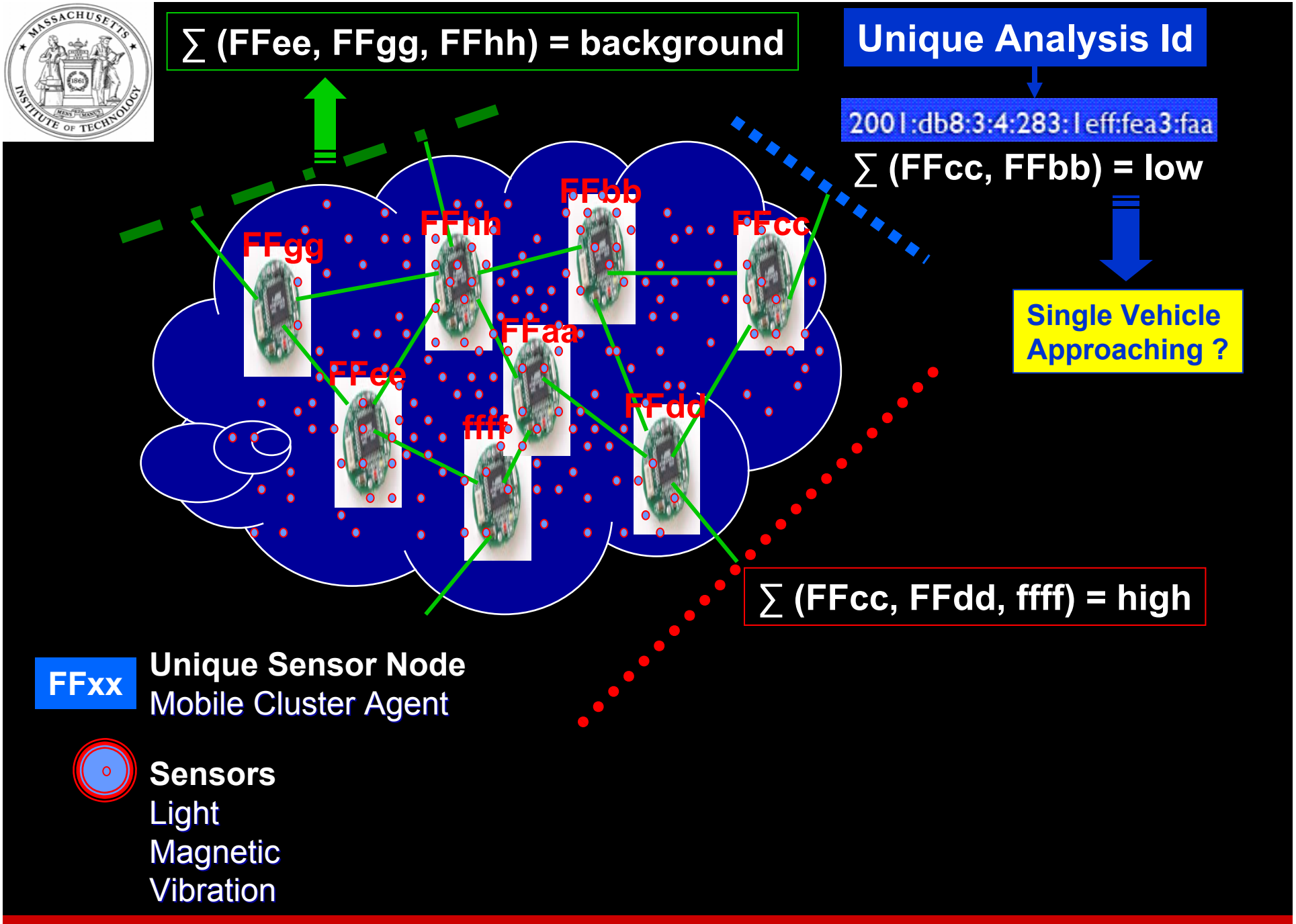
200 l :db8:3:4:283: l eff:fea3:faa

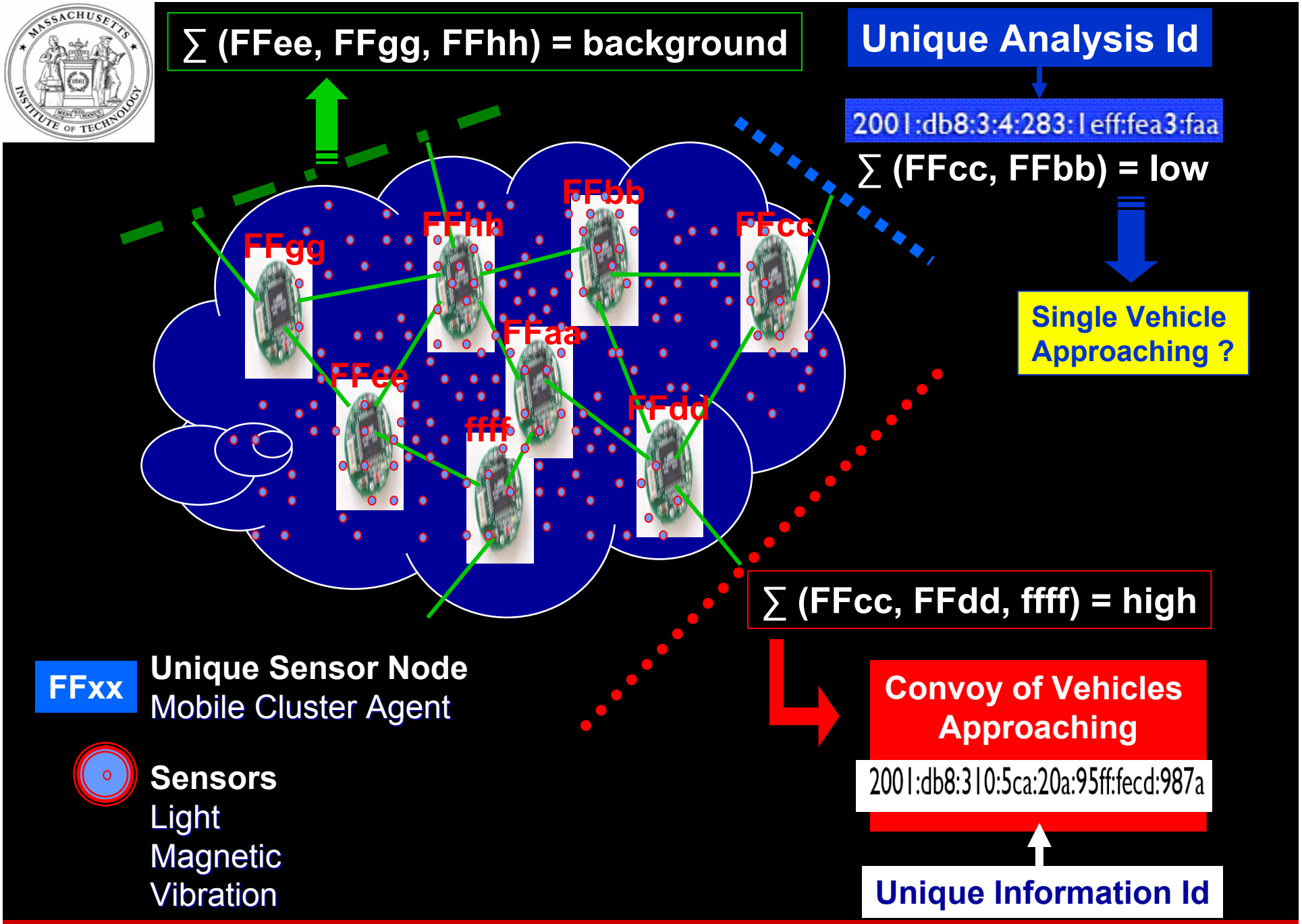
∑ (FFcc, FFbb) = low

Single Vehicle Approaching ?

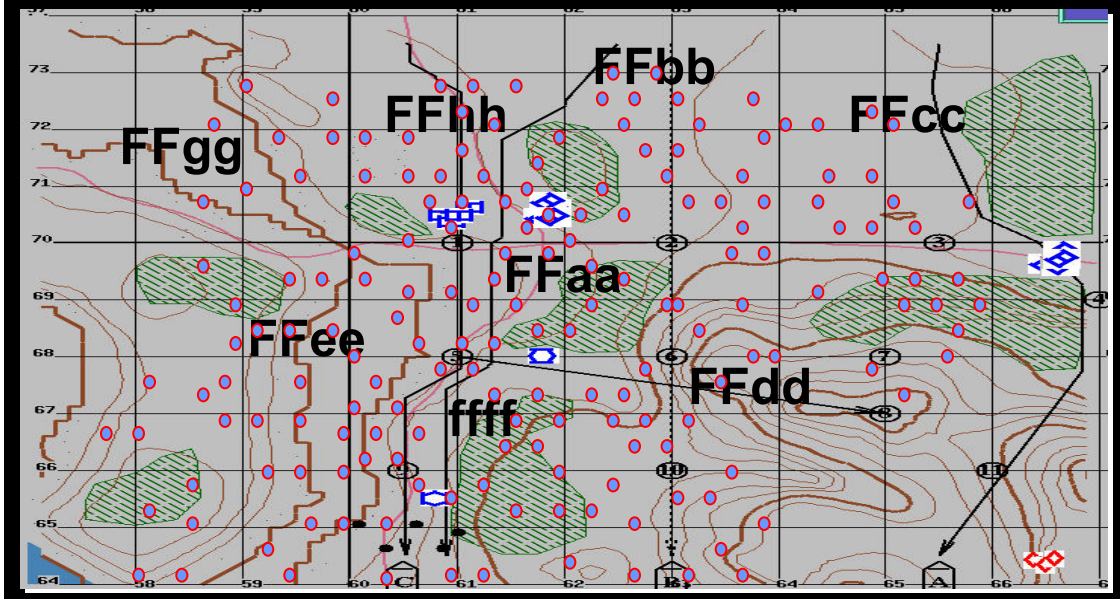
FFxx **Unique Sensor Node**
Mobile Cluster Agent

Sensors
Light
Magnetic
Vibration


∑ (FFee, FFgg, FFhh) = background
Unique Analysis Id
200 l:db8:3:4:283:l eff:fea3:faa
∑ (FFcc, FFbb) = low
Single Vehicle Approaching ?
FFgg
FFhh
FFbb
FFcc
FFaa
FFee
FFdd
ffff
∑ (FFcc, FFdd, ffff) = high
FFxx
Unique Sensor Node
Mobile Cluster Agent
Sensors
Light
Magnetic
Vibration

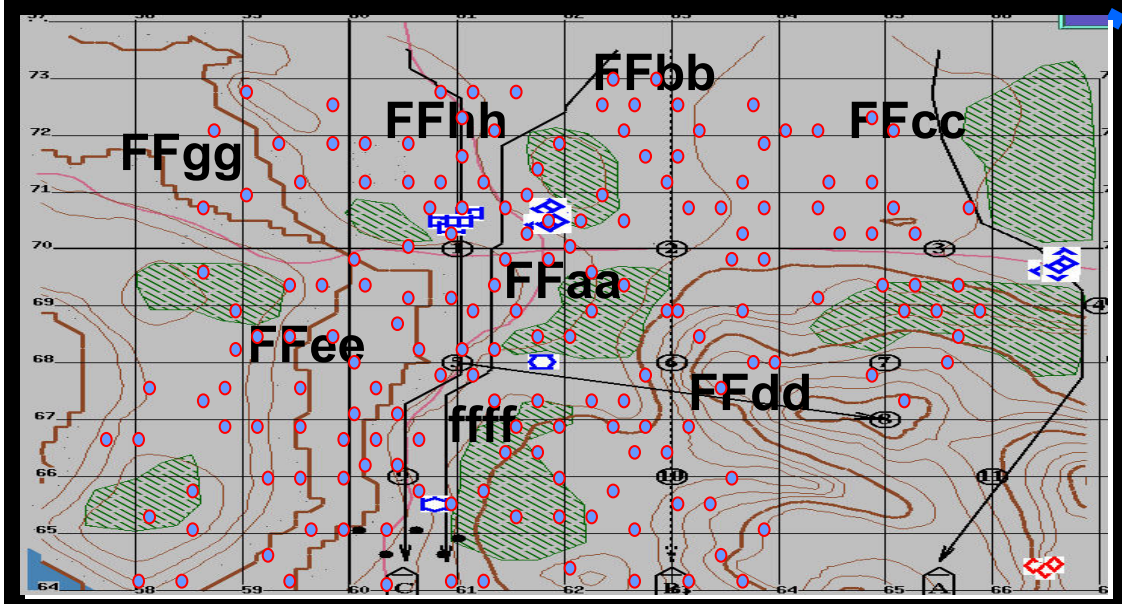

∑ (FFee, FFgg, FFhh) = background
Unique Analysis Id
2001:db8:3:4:283:1eff:fea3:faa
∑ (FFcc, FFbb) = low
Single Vehicle Approaching ?
FFbb
FFhh
FFcc
FFgg
FFaa
FFee
FFdd
ffff
∑ (FFcc, FFdd, ffff) = high
FFxx
Unique Sensor Node
Mobile Cluster Agent
Sensors
Light
Magnetic
Vibration
Convoy of Vehicles Approaching
2001:db8:310:5ca:20a:95ff:fecd:987a
Unique Information Id

War Fighter: *Answers, not Numbers*



Defense: Mobile *ad hoc* Network Decision Support Systems

War Fighter: *Answers, not Numbers*

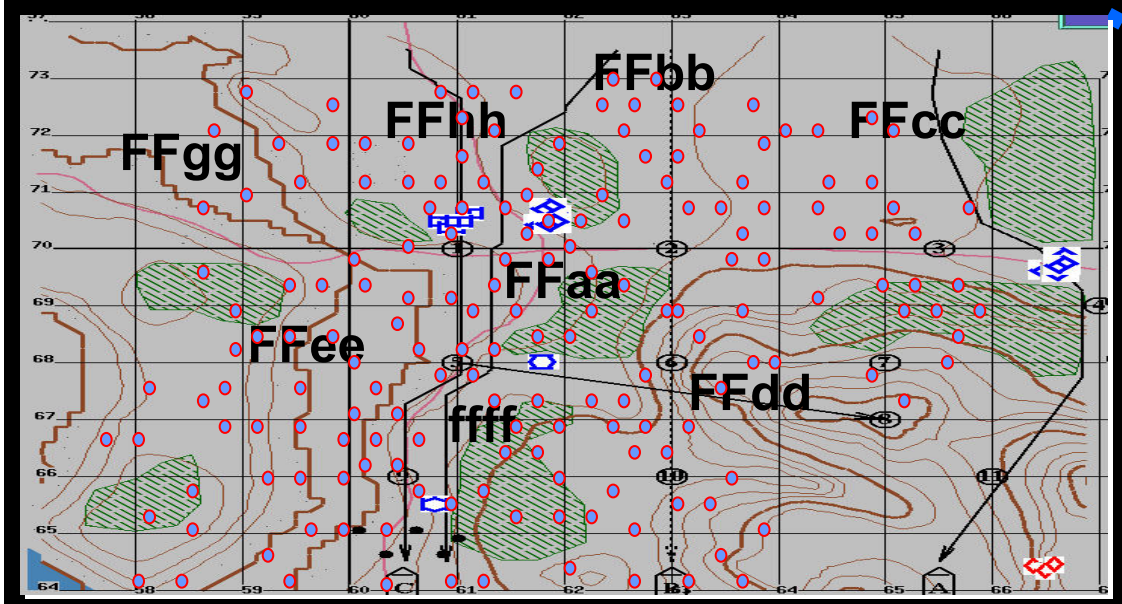


Single Vehicle Approaching ?

Large Convoy Approaching

Defense: Mobile *ad hoc* Network Decision Support Systems

Military Analysis: *Numbers*



Single Vehicle Approaching ?

Documented with unique id

- Data

- Analysis

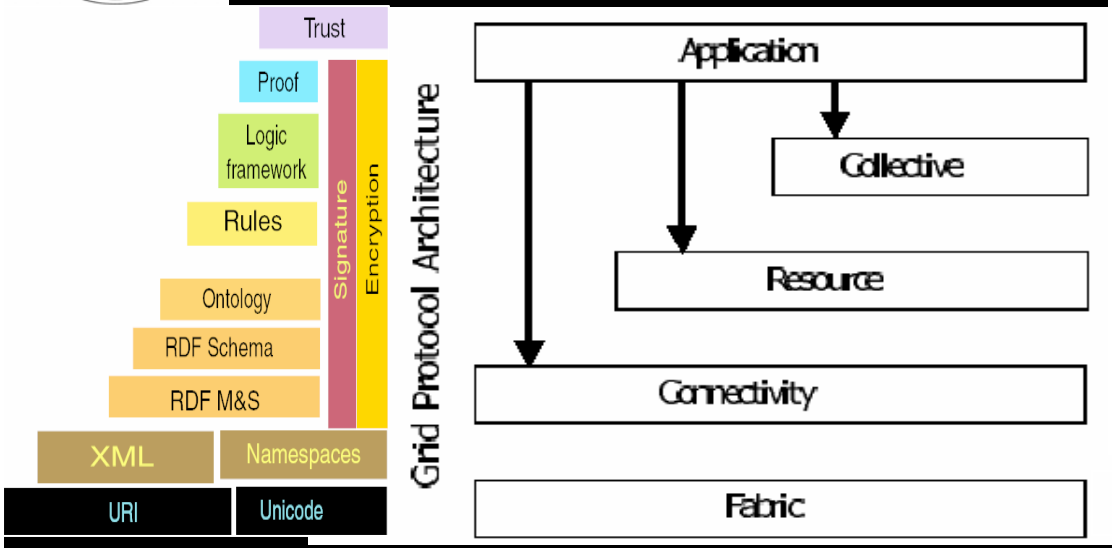
- Decision

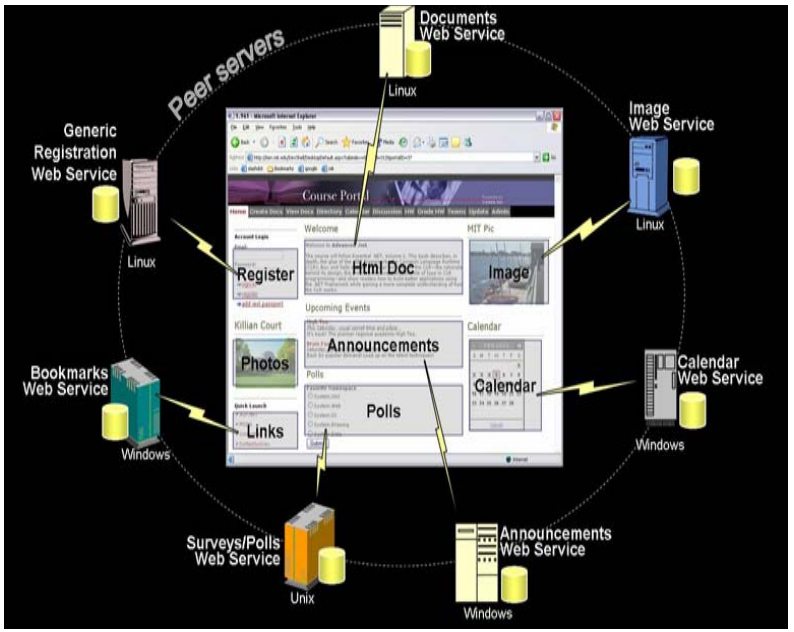
- Action

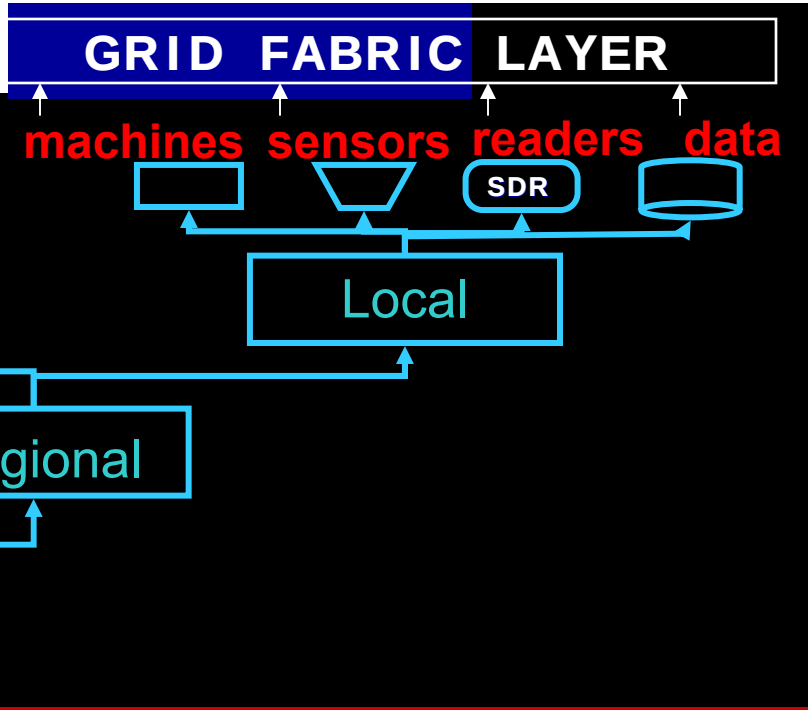
Large Convoy Approaching

Defense: Mobile *ad hoc* Network Decision Support Systems

Web X.0


Trust
Proof
Logic framework
Rules
Ontology
RDF Schema
RDF M&S
XML
Namespaces
URI
Unicode
Signature
Encryption
Grid Protocol Architecture
Application
Collective
Resource
Connectivity
Fabric

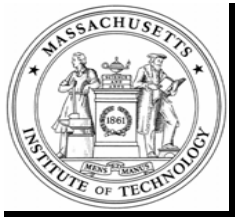

Peer servers
Documents Web Service
Linux
Generic Registration Web Service
Linux
Image Web Service
Linux
Register
Html Doc
Image
Announcements
Photos
Calendar
Polls
Links
Bookmarks Web Service
Windows
Calendar Web Service
Windows
Surveys/Polls Web Service
Unix
Announcements Web Service
Windows


GRID FABRIC LAYER
machines
sensors
readers
data
SDR
SDR
Local
Local
Regional
Regional
National

Conclusion: IPv6 Systems Solution

Offers Unique Identification for Objects, Process, Information, Decisions

- Pre-agreed for global adoption
- Systems and platform agnostic
- Syntax and semantic relationships - defined
- Data, analytics, process, information - linked



Contextual Understanding ?

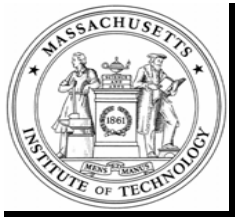
Unified Theory of Relativistic Identification of Information in a Systems Age

Convergence of Unique Identification with Syntax and Semantics through Internet Protocol version 6

How IPv6 format may be structured to be useful as an identification kit with & without normal IP functions

Automated IPv6 number stream allocation through Agent systems

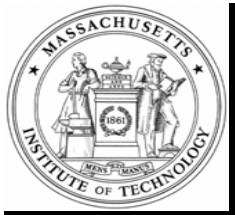
How to design IPv6 as URI sub-layer



"Did not entail being right all the time. It was rather to dare, to propose new ideas, and then to verify them and to know how to admit errors."

Professor Pierre-Gilles de Gennes* (1932-2007) after receiving the 1991 Nobel Prize for Physics

** Died 18 May 2007*



Thank you!

Questions ?

shoumen@mit.edu

Papers and Articles

relevant to this talk, please explore:

- http://groups.google.com/group/shoumen/files?hl=en
- http://supplychain.mit.edu/library/sd-papers.aspx
- http://supplychain.mit.edu/about/datta.aspx
- http://supplychain.mit.edu/shoumen

If you wish to receive a full version of this talk, please write to me by email:

Dr Shoumen Palit Austin Datta

Massachusetts Institute of Technology, Room 1-179, Cambridge, MA 02139, USA

shoumen@mit.edu

“ Dr Datta, may I be excused? My brain is full. ”